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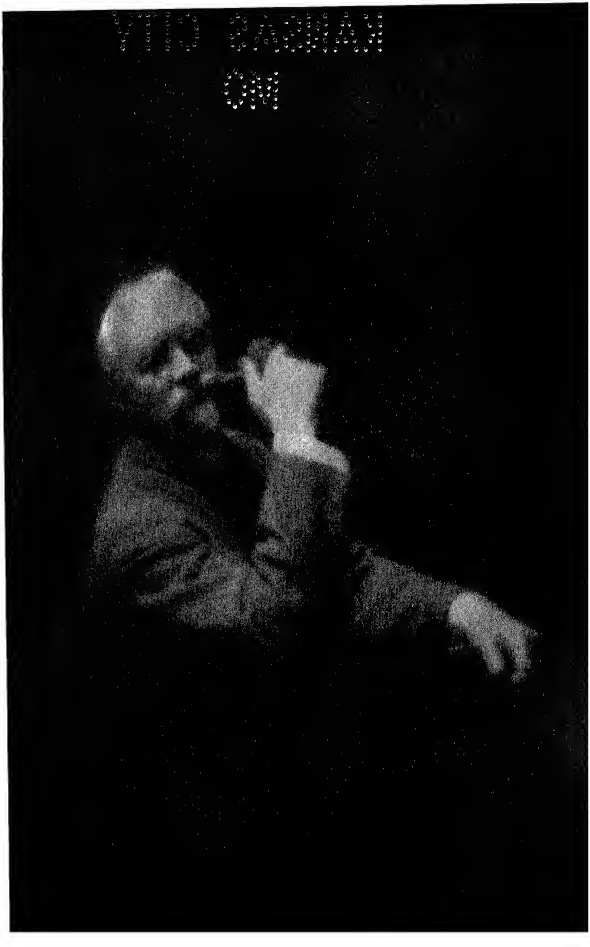
PICTORIAL PHOTOGRAPHY
ITS PRINCIPLES AND PRACTICE



PICTORIAL PHOTOGRAPHY
ITS PRINCIPLES AND PRACTICE

BY

PAUL L. ANDERSON, E.E.

WITH 25 ILLUSTRATIONS AND 35 DIAGRAMS

THIRD EDITION, REVISED

PHILADELPHIA AND LONDON
J. B. LIPPINCOTT COMPANY

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THIS BOOK IS AFFECTIONATELY INSCRIBED TO MY MOTHER AND MY WIFE, SINCE, BUT FOR THEIR ENCOURAGEMENT AND ASSISTANCE, IT WOULD IN ALL PROBABILITY NOT HAVE BEEN WRITTEN

FOREWORD TO SECOND EDITION, REVISED

In earlier editions of this book no discussion was given of ozotype and ozobrome, partly owing to the difficulty of obtaining the necessary materials, and partly because of the lack of published formulæ which would enable the worker to prepare his own solutions. Recently, however, the ozobrome process (which had been withdrawn from the market because of commercial unpopularity) has been revived under the name of carbro, and is now discussed in chapter XII since the author feels that it offers many opportunities and advantages in respect of pictorial results and manipulative convenience.

The most recent theory regards the phenomena of light as resulting from pulsations in an electro-magnetic field, but the older theory, as stated in chapter II, renders the explanation of lens and plate action much simpler and more readily grasped by the layman, and is therefore adhered to in this work.

East Orange, N. J., 1922.

FOREWORD

In preparing the discussion of the technique of pictorial photography which is given in the following pages the author's purpose has been to produce a book adapted to the needs of those workers who, without wishing to undertake a study of the abstruse scientific phases of the art, nevertheless have passed beyond the elementary stages and feel a desire for pictorial expression. Every effort has been made to adapt the book to the needs of such photographers, and for that reason the author has endeavored to make clear, not only the actual technical methods, but also the fundamental principles underlying those methods, since a thorough grasp of the principles is of importance in enabling the worker to locate and to correct his mistakes and also to study and to grow in power of expression, which is almost impossible when his knowledge is simply a matter of remembering certain arbitrary facts.

Inasmuch as pictorial photography only is being dealt with, some subjects which would otherwise find a place in a text-book have not been discussed, the most conspicuous omission of this sort being in the case of gas-light papers, which, though valuable to the commercial worker, have not great usefulness to the pictorialist, because of their lack of absolute permanence and of the highest esthetic quality. However, the author has in his own work given especial attention to the various printing processes which are of value to the pictorial worker, and feels that the discussion of

these mediums is satisfactorily complete. Attention is called in particular to the discussion of the color sensitiveness of plates, since the author's experience, both as photographer and as teacher, leads him to believe that a fuller understanding of the principles of orthochromatics inevitably results in an improvement from the pictorial standpoint.

It has seemed well to include examples of the work of noted photographers, for the sight of such work is a more powerful stimulus and incentive than any amount of verbal discussion.

The author's thanks are due to the Eastman Kodak Company and to the International Photo Sales Corporation for permission to reproduce illustrations from their catalogues; to Dr. C. E. K. Mees, of the Eastman Kodak Company, for permission to quote, in Chapter III, from his book, "Orthochromatic Filters"; to Mr. W. R. Latimer, for the comparative photographs of a colored test chart, in the same chapter, and for the valuable experimental work on carbon tissues, embodied in the table in Chapter XI; to Mr. Charles Kendall, for suggestions concerning the transferring of oil and bromoil prints; and to the photographers who have so kindly furnished prints for illustration

The author hopes that these pages, the result of several years of study and experiment, may prove of value to his readers, and may help them to a fuller expression of their artistic desires.

PAUL L. ANDERSON

East Orange, N. J., 1917

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PART I

APPARATUS

PICTORIAL PHOTOGRAPHY ITS PRINCIPLES AND PRACTICE

CHAPTER I

THE CAMERA

Function.—Fundamentally, the camera is nothing more than a light-tight box, having an arrangement for holding a light-sensitive substance (plate or film) and a device (lens or pin-hole) for projecting on this sensitive substance an image of objects external to the camera. Some of the simpler cameras approximate closely to this elementary form, but in practice other adjustments are usually added, either to make possible work which could not be done with the fundamental type, or to facilitate work of one kind or another. Some adjustments and characteristics are incompatible with others, so the design of the camera must always be in the nature of a compromise, and the instrument should be chosen with regard to the purpose for which it is desired.

Adjustments.—The ideal camera would possess the following adjustments and characteristics:

A folding bellows, operated by rack and pinion, with an arrangement for locking at any desired extension, and a maximum draw of not less than twice the focal length of the lens to be employed. (For focal length of lens see Chapter II.) As will be seen later, the farther the object is from the camera the less the bellows extension necessary, and the closer it is the farther the

lens must be from the plate in order to focus on it, a maximum extension of twice the focal length of the lens permitting of making the image the same size as the original, this being about the limit that is usually desired, except for special work, such as reproduction.

Rising and Falling Front.—That is, a device whereby the lens may be raised without the necessity of tilting the camera. This is useful in raising or lowering the image on the plate, as is indicated in Figure 1.

Traversing (or Sliding) Front.—This is an arrangement whereby the lens may be moved back and forth

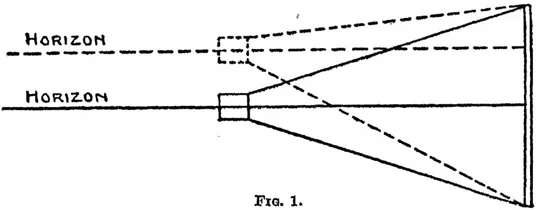

FIG. 1.

across the bed of the camera. The purpose is apparent from Figure 1.

Swing-back.—This is a device by means of which the back of the camera, together with the plate, may be swung through a small arc about either a horizontal or a vertical axis. The swing about a horizontal axis is the more important, and for pictorial work should never be omitted, the other swing being desirable but not imperative. A swing front, permitting of tilting the lens, serves the same purpose, and is sometimes furnished. Whether the swing is of the back or of the front, it should preferably be actuated by rack and pinion, and be capable of locking at any desired point.

The function of the swing-back is two-fold. In the first place, as stated above, the lens must be farther from the plate to focus on nearby objects than when the objects are more distant. Hence it follows that, say, in landscape work, it will be impossible to focus (at full aperture of the lens) on both foreground and distance simultaneously if the plate is at right angles to the axis of the lens. By swinging the top of the plate (since the image is inverted) farther from the lens the foreground and distance may be brought into focus at the same time without the necessity for using a small diaphragm in the lens (see Figure 2). In the second

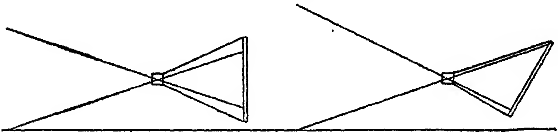

FIG. 2.

place, if we are photographing a tall object and find it necessary to tilt the camera in order to include the desired amount, parallel vertical lines will converge in the negative. If, however, the back be swung so as to remain parallel to the plane of the object (that is, vertical) this effect will not appear. This is not of much consequence in landscape work, where we rarely find parallel lines, but is of primary importance in architectural photography.

Rotating (*Usually Called Revolving*) *Back.*—This permits of arranging the plate with the long axis either vertical or horizontal as may be desired, without the necessity of turning the camera on its side. It is some-

times furnished as a reversible back, which must be detached from the camera in order to turn it, and this form is quite as desirable as the other.

In addition, the camera should be so designed and constructed as to be perfectly rigid when fully extended, should be strong enough to withstand ordinary use, and should be light and capable of being folded into a small space for transportation. For pictorial work it is also important that the front-board be large, since lenses of large aperture and comparatively great focal length will ordinarily be employed. Finally, it is strongly recommended that the student begin with a camera having a ground glass, since practice in arranging the picture is of inestimable value in the study of composition, and a view-finder is too small to make such practice possible. The miniature cameras, as well as the folding film type, valuable as they are to more experienced workers, cannot be considered desirable for beginners. In order to facilitate practice in composition, and also because a large print is undeniably more impressive than a small one, it is advised that the camera be as large as the student's strength will permit him to carry, and it will in general be found that 8×10 is about the limit in this regard for a man, and $6\frac{1}{2} \times 8\frac{1}{2}$ for a woman.

Types.—*Box Type.*—This is illustrated in Figure 3, and consists simply of a box having a lens (usually a single achromatic) in front, with a simple type of shutter, and a device for winding a roll of film so that successive portions are exposed to the image projected by the lens. Sometimes a film pack is used instead of a roll film, but the instrument is of the simplest, and need not be seriously considered here. True, good

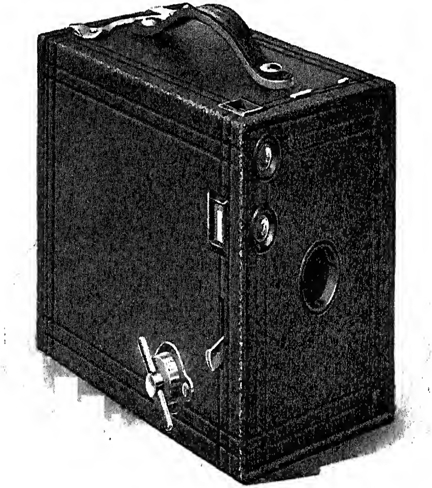

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FIG. 3.—BOX CAMERA

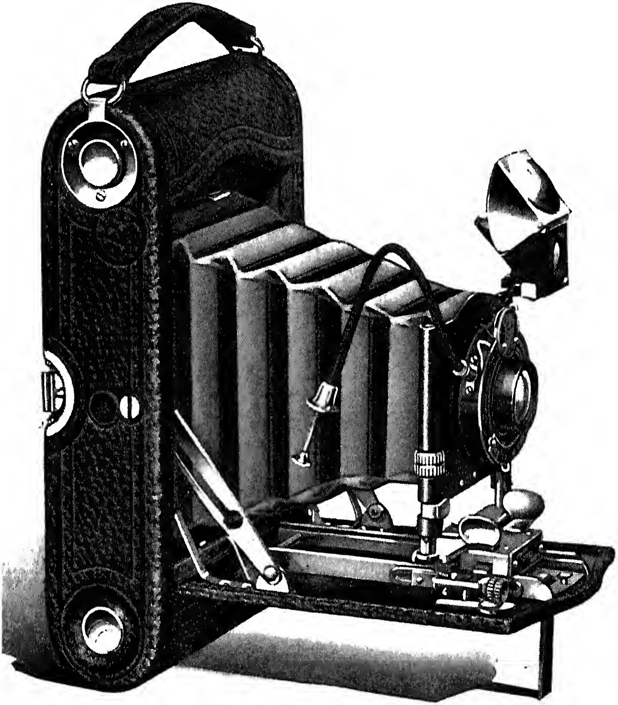

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FIG. 4.—FOLDING FILM CAMERA

work has been done with such cameras, but only under the most favorable circumstances.

Folding Film Type.—This next higher development of the camera (Figure 4) adds the extensible bellows, the rising and falling front (as a rule) and ordinarily has a rapid rectilinear lens, though the objective is sometimes a single achromatic and sometimes an anastigmat. The shutter is more complete in its adjustments than that of the box type, and may, in fact, be the highest type of between-lens shutter. In some cases the focal plane shutter is used, and, in general, this type of camera may be considered the best form of snapshot instrument except the reflex. The folding film camera, however, lacks the large front-board, the long bellows extension, the swing-back, and, as a rule, the focussing screen, so it cannot be considered a desirable instrument for the pictorial worker, being, in fact, designed for record work when compactness and portability are of importance. It is, however, possible to secure ground glass attachments for most cameras of this type, thus extending their usefulness.

Reflex Type.—This camera is the best for snap-shot and high-speed work, and the writer's experience, as well as that of many well-known workers, indicates that it may be very useful to the photographer whose aim is purely pictorial, some artists even going so far as to discard all other types in favor of this one. As shown in Figure 5, a mirror is hinged at an angle of 45° to the axis of the lens, the image being projected on the mirror and reflected by it on a horizontal ground glass, where it may be examined by looking down into the hood. Pressing a lever at the side of the camera

releases the mirror, which flies up to a horizontal position, allowing the image to be projected on the plate or film, and at the same time operating the shutter, which is of the focal plane type. The advantages of this arrangement are that it is possible to focus on the object up to the instant of exposure, that very brief exposures (up to 1/1600 second) are possible, that the light-efficiency of the focal plane shutter is higher than that of any other type, and that instruments of this sort are available with all desirable adjustments. The only disadvantages lie in the facts that such cameras are rather bulky and heavy, the weight becoming prohibitive in sizes larger than 5×7, and that they are expensive.

The Folding Hand Type.—This type, illustrated in Figure 6, varies greatly in design, being, in general, compact and light, and being obtainable with all desirable adjustments. So far as the writer knows, no camera of this style now made in America has a large front-board or the swing about a vertical axis, though one such was made in this country some years ago, and some English instruments possess these characteristics. With these limitations, this type is highly commendable, though somewhat expensive.

The View Type.—This camera (Figure 7) is the one which the writer recommends most strongly to both students and advanced workers, since it can be had with all desirable adjustments and is relatively cheap, the only drawbacks being the bulk and weight.

The Studio Type.—As the name implies, this camera (see Figure 8) is designed especially for use in the portrait studio, and, though possessing all adjustments, is too bulky and heavy to be carried about, this fact

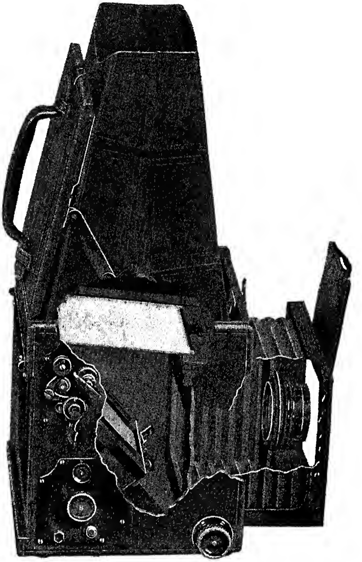

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FIG. 5.—SECTIONAL ILLUSTRATION SHOWING PRINCIPLE OF REFLECTING CAMERA

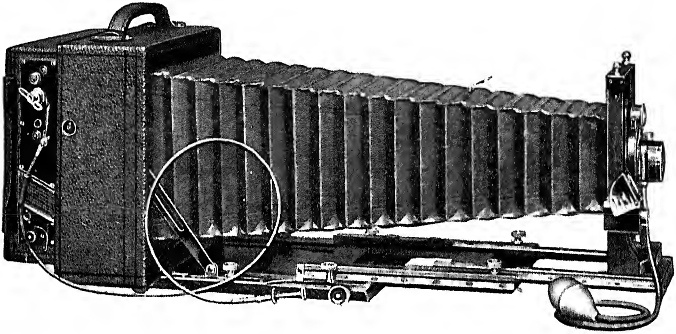

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FIG. 6.—FOLDING HAND CAMERA

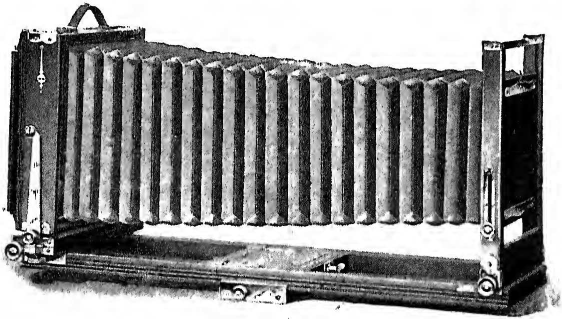

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FIG. 7.—VIEW CAMERA

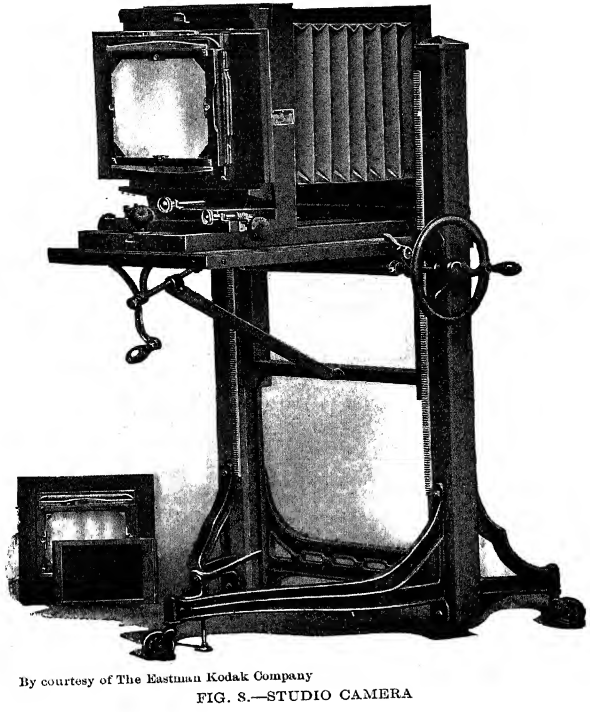

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FIG. 8.—STUDIO CAMERA

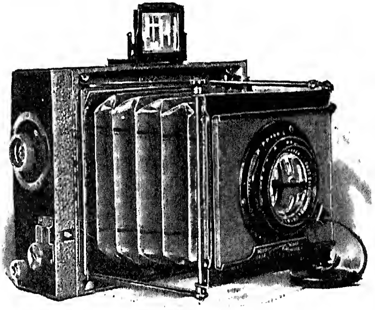

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FIG. 9.—MINIATURE CAMERA

rendering it unavailable for landscape and genre work, as well as for home portraiture.

The Miniature Type.—There are many designs of this camera, one of which is shown in Figure 9, such instruments generally having high grade lenses and shutters, but being designed with a view to extreme portability. They are light and compact, and are therefore exceedingly desirable for record work, especially when travelling, but are not to be recommended to the pictorial worker unless he has had a good deal of experience with a camera having a focussing screen, in which case they may be very valuable.

As already indicated, the writer would advise that the student begin with a view camera or (if cost is not important) one of the folding hand type, 8×10 or 6½×8½, and when experience in composition has been gained procure in addition one of the reflex type, 4×5 or 3¼×4¼, since the latter, being more portable and easily operated, will often be of use when the larger camera would have to be left at home. In addition, the reflex will be found of great value when photographing children, no other camera being comparable with it for this purpose.

There are many different makes of each of these types, but so far as the writer knows there is none which cannot be recommended as regards construction. The camera should, except in the case of the box, folding film, or miniature type, be purchased without a lens, since the manufacturers almost invariably fit lenses of too short focal length for pictorial work, and do not furnish objectives of the type most useful to the artist except on special order.

CHAPTER II

THE LENS

Wave Theory of Light.—If we stand beside a pond of still water and throw a stone into it we shall see a series of waves passing out in concentric circles from the center of disturbance. If there be a chip or a leaf floating on the surface it will be apparent, on watching this object, that there is no forward motion of the water itself (unless the stone be so large relatively to the pond as to cause a marked displacement of the water) but that the individual molecules simply rise and fall in a vertical direction, each communicating its motion to the next, so that the wave travels forward. The accepted theory regards the propagation of light as being due to a similar wave motion in the luminiferous ether, an invisible, imponderable substance pervading all matter, the wave motion originating in any self-luminous body.[1] The motion of water particles is represented diagrammatically in Figure 10, which shows two complete waves, but it must be understood that whereas the water particles vibrate only vertically,[2] at right angles to the axis of translation of the wave, the ether particles vibrate at right angles to this direction, and in all azimuths to it, that is, vertically, horizontally, obliquely, etc. The

[1] One theory regards the propagation of light as consisting of a series of irregular pulses which are transformed into a simple harmonic motion on encountering any material obstacle, but since we are dealing with light only after it has encountered such obstacles the above statement may be taken as correct.

[2] Actually, in small vertical circles.

distance, A—B, from the crest of one wave to that of the next, or, more generally, from any point in a wave to the point which is in the same phase in the next wave, is known as the wave length. Unless artificially deflected, light tends to travel in straight lines, but it may be reflected or refracted, that is, bent, and it is upon this principle of refraction that the action of a lens depends.

Refraction of Light.—Consider now the case of a ray of light, travelling in a straight line, and encountering a plane, parallel-sided sheet of glass. If the ray meets the glass normally it will simply be retarded, since light travels more slowly in a dense medium than in a rarer

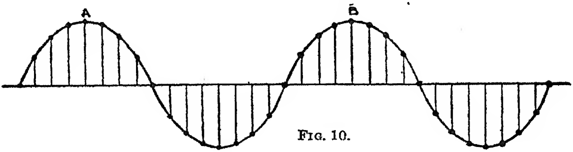


Fig. 10.

one, but if it meets the glass at any angle other than a right one the edge which first reaches the glass is retarded more than the other, since the latter is still travelling in air. On emerging from the glass the reverse takes place, and the ray resumes its former direction, having merely been displaced laterally (Figure 11). If, however, the faces of the glass are not parallel, the ray is refracted differently, as shown in Figure 12, where a prism of glass is represented. Here the edge B—B′ is retarded less than the edge A—A′, so that the ray is bent toward the base of the prism, and if sufficiently produced will meet the produced base at some point, the distance of this point from the prism

depending on the angle of the prism, the kind of glass of which it is made,[3] and the angle at which the incident ray meets the prism.

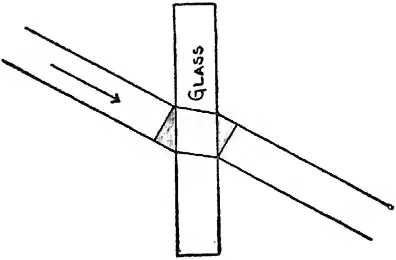


FIG. 11.

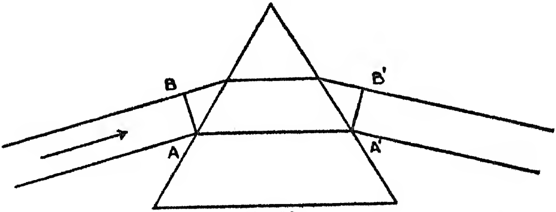


FIG. 12.

[3] The extent to which the ray is bent depends on the refractive index of the glass, and the refractive index is defined as follows. If we measure the angle, I, which a ray of light incident upon a transparent plane surface

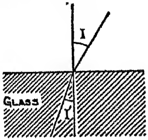


FIG. 13.

makes with the normal to the surface, and the angle, I', which the ray makes with the normal after refraction, it will be found that the ratio of the sines of these angles is constant for a given substance. This ratio, $\frac{\sin I}{\sin I'}$ is called the refractive index of the substance.

Every point of every natural object sends out rays of light in all directions, either originating in the object or reflected by it, and in ordinary photographic work those rays which reach the lens may be considered parallel, since the diameter of the lens is usually small compared to the distance which the rays travel before reaching it. If, now, two prisms be placed with their bases together, as in Figure 14, the two rays, if equidistant from the axis, will obviously meet on the other side of the prisms, and will form an image of the point

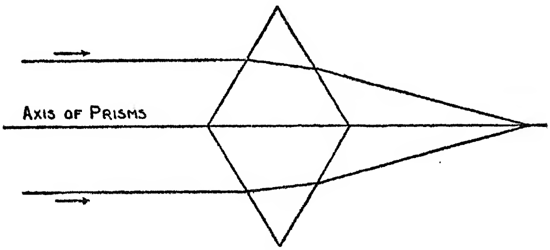


Fig. 14.

from which they come. Since a spherical surface (the only kind which can be accurately ground except at a prohibitive expense) may be considered as made up of an infinite number of triangles, it follows that all rays of light emanating from a point and falling on a lens will be converged by the lens and will form an image of the point from which they come, and this is the case for all points of the object, the sum of the images of the points constituting an image of the object. Since the degree of refraction is a fixed function of the quality

of the glass and the curvature of the surface, it follows that rays meeting the lens at a more acute angle than others will emerge at a more obtuse one, this being the reason for the necessity for setting the ground glass

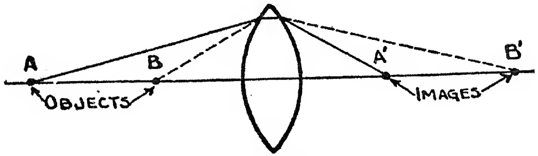


FIG. 15.

farther from the lens when focussing on a near object than when focussing on a more distant one. A consideration of Figure 15 will make this clear.

FORMATION OF THE IMAGE.—We have seen that a lens forms an image of an object placed in front of it, but for the sake of clearness this is illustrated in Figure 16,

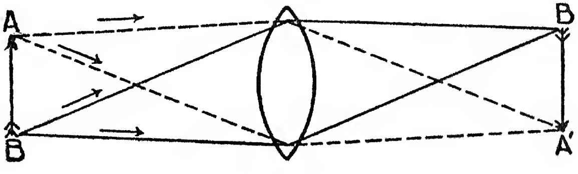


FIG. 16.

where two rays from each of two points are considered. This also indicates the reason for the inversion of the image on the ground glass.

FOCAL LENGTH OF A LENS.—The focal length (often

incorrectly called focus) of a lens is the distance from the lens to the point at which rays originally parallel meet after refraction, this definition being of importance.[4] The focal length is illustrated in Figure 17, and depends on the design of the lens, that is, the curvature of the surfaces and the kind of glass used. In a double lens, which consists of two single lenses mounted at opposite ends of a barrel, the focal length must be measured from the optical axis of the combination, and this point usually coincides with the

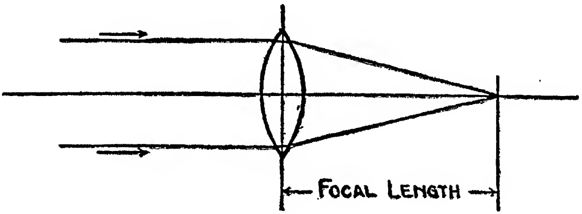


FIG. 17.

diaphragm, so that the focal length may be measured from this point, the determination in this manner being sufficiently accurate for practical purposes. To find the focal length of a lens, set the camera up and focus as sharply as possible, at full aperture of the lens, on some object more than a hundred feet away. Measure the distance from the ground glass to the lens, if a

[4]This is not strictly correct, since it assumes that the nodal planes coincide with the central plane of the lens, which is true only in the case of an infinitely thin lens, but for practical purposes it may be considered to be the case. For a description of the nodal planes the reader is referred to "The Lens," by Bolas and Brown, or to "Photographic Lenses," by Beck and Andrews.

single lens, or to the diaphragm, if a doublet. This will be the focal length of the lens, and an error of 1/8 or even 1/4 inch will not be of importance to the pictorialist. This method is not applicable to telephoto lenses.

Dispersion of Light.—If a ray of white light be allowed to fall on a prism, as in Figure 18, it does not emerge as a ray of white light, but as an elongated band of different colors, thus proving that white light is a compound. This separation is known as dispersion, and it has been found to be due to the fact that white light does not consist merely of rays of one definite

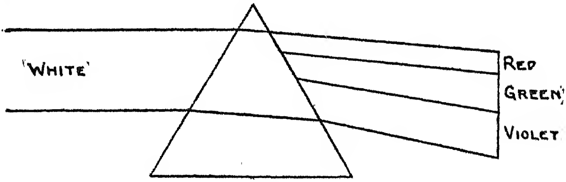


Fig. 18.

wave length, but is a synthesis of rays of many lengths, the waves of different lengths being refracted differently, and it has also been found that the rays of shorter wave length are refracted more than those of greater length. Different portions of the retina are sensitive to waves of different lengths, those waves from 4000 to 5000 A. U.[5] in length giving rise to a sensation of violet, those from 5000 to 6000 to one of green, and those from 6000 to 7000 to one of red, the mixture of these in proper proportions causing a sensation of white.[6]

[5] A. U. is the abbreviation for Angström unit, the unit being 1/10,000,000 of a millimeter.

[6] These figures are approximate only.

Chromatic Aberration.—It will be apparent that a lens which analyzes white light cannot give a sharp image of any point which sends out rays that are not purely monochromatic, and this defect is known as chromatic aberration, being illustrated in Figure 19, where the violet rays, being of shorter wave length than the green, are more refracted, and are brought to a focus nearer the lens than the latter, these in turn being focussed nearer the lens than the red. Since the focal length of a lens depends fundamentally on the curvature of the surfaces, and the dispersion de-

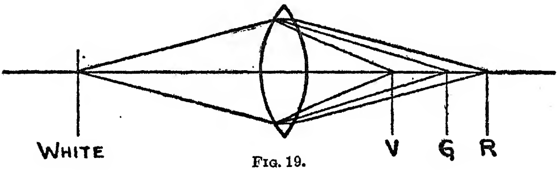


Fig. 19.

pends fundamentally on the type of glass, it follows that by combining two kinds of glass of different dispersive powers, ground to different focal lengths, it is possible to produce a lens which will converge the rays but will not disperse the different wave lengths, and such a lens is said to be achromatic, or free from chromatic aberration. It should be noted that no lens which consists of a single piece of glass, such as a spectacle lens, or the Struss Pictorial Lens, can be achromatic.

Spherical Aberration.—This optical error is due to the fact that a lens having surfaces which are portions of a sphere converges the rays passing through

near the margins and those passing through near the axis at different distances from the lens, as is illustrated in Figure 20. This has nothing to do with dispersion, the present error manifesting itself with monochromatic as well as with compound light. Spherical aberration depends fundamentally on the curvature of the lens surface, and may be either positive or negative, that is, the marginal rays may be brought to a focus either nearer to or farther from the lens than the axial. It is possible to grind lenses of the same focal length in a variety of shapes, and spherical aberration is corrected by combining two lenses of different focal lengths in

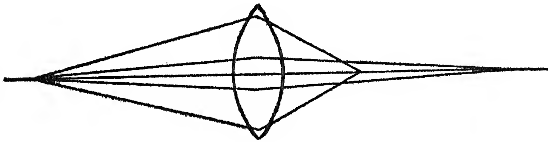
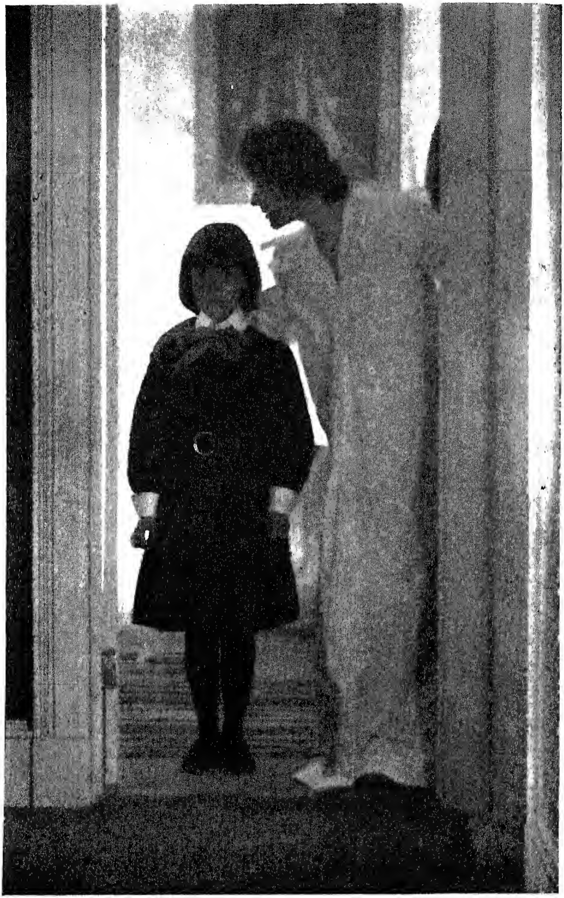


FIG. 20.

which the error is of the same magnitude but opposite in sign, thus producing a lens which converges rays of light but has no outstanding spherical aberration. It should be noted that if the two surfaces of the lens have different radii of curvature spherical aberration is less when the more deeply curved one (the one having the smaller radius) is toward the parallel rays than in the reverse case, as is illustrated in Figure 21, where A and B show the same lens, turned in different directions. Hence, if one of the combinations of a lens is removed for cleaning, or if a single lens is taken out



BLESSED ART THOU AMONG WOMEN
BY GERTRUDE KÄSEBIER
From a Platinum Print

of the barrel, care must be used to see that it is replaced in the proper manner.

Curvature of the Field.—Curvature of the field is that defect in which the image of a plane surface is projected, not as a flat plane, but in a saucer-shaped envelope, the edges of the image being usually nearer the lens than the center. Obviously, if a lens has this defect a flat plane cannot be brought to a focus on the plate, for if the center is sharp the edges will be out of focus, and *vice versa*. The best approximation to a

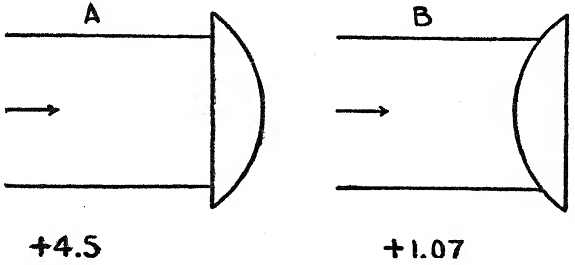


Fig. 21.

focus is got by setting the plate midway between the focal plane of the center and that of the edge, when the diffusion of center and edge will be only half what it would be for either if the other were sharply focussed. Curvature of the field is corrected by designing the lens so that the focal length is somewhat greater for the edges of the field than for the center.

Flare.—Flare is not, properly speaking, an inherent optical defect, but is due to faulty design. When a ray of light passes from one medium to another of

different density (or, more correctly, of different refractive index) a portion of the light is reflected from the junction of the two media. Hence, when light falls on a lens part passes through and part is reflected from the second surface. This last part may be reflected again from the first surface and again pass through the lens, falling on the plate at a point different from that where the original ray falls. If these secondary rays converge near the plate we may have a definite secondary image of the originating point, this being

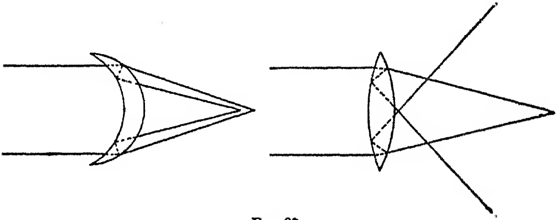


FIG. 22.

the worst form of the defect, and being called flare spot, but if they converge at a point remote from the point of convergence of the principal rays they may simply cause a general illumination of the plate, resulting in slightly less brilliant negatives than if flare were absent. These two conditions are illustrated in Figure 22. It will be apparent that an anastigmat, which has three or five, or even more, reflecting surfaces, will be more likely to show flare than a single lens, which has but one such surface,[7] and this fact is of importance

[7] A cemented surface does not cause flare, since the refractive index of Canada balsam (which is used to cement the elements together) is nearly that of glass.

to the pictorialist, who does much of his work against the light, flare being, of course, more conspicuous when working in this manner than when no very brilliant light is included in the field of view.

Distortion.—Distortion is unavoidable in a single lens, and is that defect which results in straight lines near the edges of the field being rendered not as straight,

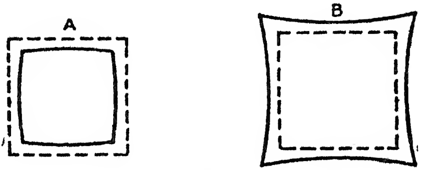


Fig. 23.

but as slightly bowed. If the diaphragm is in front of the lens (that is, between the lens and the parallel rays) the bowing will be convex (barrel-shaped) as in Figure

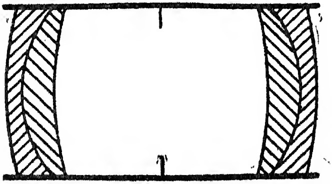


Fig. 24.

23A, whereas if it is behind the lens the distortion will be concave (pin-cushion) as in Figure 23B. The dotted lines show the position which the image should have.

Distortion is corrected by mounting two similar lenses at opposite ends of a barrel, as in Figure 24, with the diaphragm symmetrically placed between them, when the barrel-shaped distortion of the one balances the pin-cushion distortion of the other, and such a lens is known as rectilinear. If the combinations are not similar, the diaphragm is placed nearer one than the other, for the farther the diaphragm is from the lens, the greater the distortion. Hence, if the combinations of an asymmetrical objective are removed from the mount, care must be taken to see that they are replaced in their proper relative position. Since distortion does not exist in lines coinciding with the axes of the plate, and grows progressively worse toward the edges of the field, it follows that if the lens has a focal length which is large relatively to the size of the plate used, so that the plate occupies only a small portion of the entire image projected by the lens, distortion will not be excessive, and in any case it will not appear unless the picture includes straight lines, such as are found in architectural subjects, so that a lens having distortion may be used with perfect satisfaction for landscape and portraiture.

ASTIGMATISM.—Astigmatism is that defect in which bundles of rays passing obliquely through the lens near the margin are converged, not to points, but to straight lines. Each such bundle is converged to two straight lines at different distances from the lens and at right angles to each other, or, rather, it is converged to a line, and after passing the point of convergence it diverges again to another line. Astigmatism is difficult to illustrate graphically, but may be understood by anyone

who will roll up a truncated cone of paper and pinch the small end to a straight line, afterward pinching the cone to another straight line at right angles to the first and at some distance from the end. The straight lines represent the projection of a point of the object, whereas if the lens were free from astigmatism this projection would be represented by rolling the paper so as to form a complete cone, the small end being a true point. It should be noted that astigmatism appears only at the margins of the field, so will not be noticeable if the lens is of great focal length relatively to the plate used. The practical result of astigmatism is to render it impossible to focus simultaneously on vertical and horizontal lines in the same plane and lying near the edges of the field, so that if the image of a tree, for instance, comes close to the edge of the plate the trunk will be sharp and the branches blurred, or *vice versa,* but it will not be possible to get both sharp at once, except by using a small diaphragm.

TYPES OF LENS.—*Spectacle and single meniscus.*—The spectacle lens is simply a double convex piece of glass, such as an ordinary pocket magnifying lens, and the single meniscus is a concavo-convex lens with different radii of curvature for the two surfaces. There is on the market an objective of the latter type, the Struss Pictorial Lens, especially designed for pictorial work, such a lens possessing all possible errors, and giving, as a result of its optical defects, a very soft and pleasing quality of definition.

Single Achromatic.—As indicated above, the single achromatic lens consists of two pieces of glass cemented together, and so designed that the yellow (green+red)

rays are brought to a focus at approximately the same distance from the lens as the violet, these latter being the most active chemically, whereas the yellow are the most luminous to the eye. Such a lens is generally partly corrected for spherical aberration, and is not likely to show flare, but has all the other optical errors. In general it gives somewhat sharper definition than the simpler types, but there are a number of pictorial lenses, such as the Pinkham and Smith Semi-Achromatic and Visual Quality, the Wollensak Verito, the Spencer Port-Land, and others, in which chromatic aberration is only partly corrected, so that a soft definition is obtained. It must be understood that in the objectives named, as well as in the Struss lens, the lack of correction is intentional, such lenses being known as "soft-focus" or "pictorial" lenses.

Rapid Rectilinear.—This objective consists of two single achromatics mounted as shown in Figure 24, and is usually corrected for chromatic and spherical aberration, and, of course, for distortion, but has curvature of the field and astigmatism, and is more likely to show flare than the simpler lenses. The result of mounting two similar lenses in this manner is that the combination has half the focal length of either of the elements, so that if a long-focus lens is desired one of the elements may be removed from the barrel and the other used alone. This fact will be referred to later, in discussing diaphragms.

Anastigmat.—This is corrected for all optical errors, but may show flare, the writer having seen an objective of this type from one of the most favorably known makers which possessed a marked flare spot, and for

this reason, if for no other, would be useless for pictorial work.

It must be understood that it is impossible to correct absolutely for any error, that is, to make the lens render the image of a point of light as a true point, over the entire field of the objective, and an approximation is all that can be expected. The result of any optical error is to make the image of a point appear as a circle of appreciable diameter, and the purpose of the designer is to reduce the diameter of such a circle, known as a "circle of confusion," to a size which will be inappreciable to the unaided eye, the ideal striven for being usually 1/200 inch. Further, this cannot be attained over the entire field of the lens, so the designer endeavors to attain his ideal over as large an angle as possible. Hencc, when a lens is said to be corrected for any fault, it means that the circles of confusion due to this error do not exceed about 1/200 inch in diameter over the size plate for which the lens is listed. If used on a larger plate the error will become apparent.

There are other types of lens than those mentioned above, such as the periscopic, which consists of two single meniscus lenses mounted as shown in Figure 24; the Petzval portrait lens, which has great speed and microscopic definition over a small angle, but has little covering power, so that the objective must be of great focal length as compared to the plate; and the apochromat, which is the highest type of anastigmat: but the first two are seldom met nowadays (except that the Struss doublet is of the periscopic form) and the last is of value only to the process worker or micro-

scopist, or, in general, to those workers who require extremely fine definition.

So far as definition is concerned, the objectives enumerated are arranged progressively in order of increasing accuracy, the single lenses giving the softest drawing and the anastigmat the most exact. Since the normal eye has chromatic and spherical aberration, and in many cases astigmatism exists as an abnormality, it follows that an objective which gives microscopic definition cannot render objects as they appear to the observer. The pictorialist generally wishes to represent objects in this manner, so he will do well not to select an anastigmat, a rapid rectilinear, or even a single achromatic, but to choose one of the soft-focus lenses, since these, when used wide open, give a pleasing quality, and may be made to give definition equal to that of an anastigmat by the use of a small diaphragm.

Diaphragms.—It now becomes necessary to consider the matter of diaphragms. These are devices of various sorts, so arranged that a portion of the rays which would ordinarily pass through the lens may be excluded, the proportion excluded depending on the size of the aperture in the diaphragm. The types of diaphragm are (1) rotary, consisting of a metal plate with circular holes of different sizes, so arranged that by rotating the plate the desired aperture is brought in front of the lens; (2) Waterhouse, consisting of several plates with different sized holes, the desired plate being slipped into a slot in the lens barrel; (3) iris, consisting of a number of thin curved plates, overlapping and arranged so that the rotation of a ring causes the plates

to move toward a common center, thus diminishing the size of the aperture. In single lenses the diaphragm is practically always placed in front of the glass, and in compound lenses between the combinations. Since spherical aberration and astigmatism are due to the marginal rays it follows that if these rays are excluded the errors disappear, and it will be obvious that if only the axial rays are used in forming the image these will approach the plate at a more acute angle than the marginal rays (see Figure 19) so that chromatic aberration will be less apparent, curvature of the field being at the same time rendered less conspicuous for the same reason. Hence, all optical errors except distortion and flare may be corrected by the use of a small stop,[8] and it follows that the only advantage of the anastigmat is that it gives fine definition at a larger aperture, and consequently with briefer exposures, since the more light that passes through the lens, the less the time required for it to produce the desired chemical effect on the plate.

Depth of Field and Depth of Focus.—If the camera be set up and focussed as sharply as possible on some object a short distance away it will be found that objects slightly nearer and slightly farther away are also in focus, so far as can be seen by the unaided eye. The distance from the nearest to the most remote of the objects apparently sharp is known as the depth of field (often incorrectly called depth of focus). It will also be found that if a given object is sharply

[8] There is a pseudo flare which results from the reflection of light by bright surfaces inside the lens barrel, and this may often be diminished by the use of a small stop. Obviously, however, the best way to prevent this form of flare is to have the inside of the barrel properly blackened.

focussed on it is possible to move the ground glass and the lens slightly nearer together or farther apart without visibly impairing the definition of the object in question. The distance through which the ground glass (or the lens) may be moved is known as the depth of focus. Obviously, the depth of field and depth of focus depend on the manner of observing the image, since if a magnifying lens is used to examine the image on the ground glass faulty definition becomes more apparent than it would be to the unaided eye, the circles of confusion being magnified. The use of these terms therefore implies that no magnifier is used.

Depth of field and depth of focus are functions of the focal length of the lens and of the size of the stop used, being inversely proportional to these characteristics. That is, they are greater in a short focus lens than in one of greater focal length, and are greater with a small stop than with a large one, this latter fact being due to the circumstance that the axial rays converge at a more acute angle than the marginal. Hence, all lenses of the same focal length and the same aperture are identical as regards depth of field and of focus, the frequent claim of the manufacturer that his lenses have great depth meaning simply that they are so well corrected that one of relatively short focal length may be employed with a given size of plate. It should be noted that the soft focus lens, or, in fact, any uncorrected objective, has greater apparent depth, both of field and of focus, than the more highly corrected lens, since if no plane is sharply defined the difference in definition between the one which is most

accurately defined and those which are out of focus is less apparent than when one is microscopically sharp.

In fixed focus cameras lenses of short focal length and small aperture are employed, the result being that the depth of field extends from a point about six feet from the camera to infinity, thus obviating the necessity for focussing. Such cameras are sometimes called "universal focus."

Diaphragm Markings.—It is obvious that if a small aperture is used less light will reach the plate in a given time than with a large one, and, since the sensitive emulsion has some inertia, that is, requires some light to produce any chemical action whatever, a longer exposure will be necessary if a definite effect is to be obtained. The markings of the apertures furnish an indication of the relative exposures necessary with the various stops, and there are two systems of marking in common use, the F system and the uniform system (abbreviated to U. S.). In the former the number expresses the fraction which the diameter of the aperture is of the focal length of the lens, that is, F/8 means

$$\text{diameter of aperture} = \frac{\text{focal length}}{8},\ \text{F/11 means}$$

$$\text{diameter of aperture} = \frac{\text{focal length}}{11},\ \text{etc.}\quad \text{Since}$$

the time of exposure varies inversely as the area of the stop, and since the areas of circles are directly proportional to the squares of their diameters, it follows that the ratio of exposures required with different stops is

the ratio of the squares of the F numbers. Thus, F/16 will require four times as much exposure as F/8, since

$(16)^2 = 256$ and $(8)^2 = 64$, and $\frac{256}{64} = 4$. Stops are

usually marked in such a series that each requires twice as much exposure as the next larger, the F series being F/4, F/5.6, F/8, F/11.3 F/16, F/22.6, F/32, F/45, F/64, etc. Intermediate numbers, such as F/6.8, F/7.7, are sometimes used, when these represent the largest aperture of the lens. In the uniform system F/16 is taken as the arbitrary unit, and is called U. S. 16, the other apertures being so marked that the ratios of the exposures are directly as the ratios of the numbers, the actual diameters of the openings, in inches, remaining the same as in the F system. The table below shows the relation between the two systems, and the exposures required:

F System	Uniform System	Relative exposure in seconds or minutes
4	1	1
5.6	2	2
8	4	4
11.3	8	8
16	16	16
22.6	32	32
32	64	64
45	128	128

There are other systems, but they are comparatively little used.

It should be noted that when one combination of a symmetrical lens is employed the stop markings no longer represent the true values of the apertures. Thus, suppose the case of a rapid rectilinear lens of eight

inches focal length, working at a maximum aperture of F/8. When one combination only is used the focal length becomes sixteen inches (8×2). Since the aperture of the whole lens is F/8 and the focal length eight inches, it follows that the aperture has a diameter of one inch, and the working aperture of the single combination becomes F/16 (16/1 = 16). Hence the single combination will require four times the exposure of the doublet.

Speeds of Lenses.—Returning now to the matter of lenses, it has been explained that a high grade lens is one which has been so well corrected for optical errors that it will give fine definition at a large aperture, but that the same result may be attained with an uncorrected lens by stopping down, and the following table gives a general idea of the largest apertures at which different types of lens work, though it must be understood that these figures are not fixed, but vary with different manufacturers:

Type of Lens	Sharp Definition	Pictorial Work
Spectacle and single meniscus	F/16	F/5.6 [9]
Single achromatic	F/11	F/6 [9]
Rapid rectilinear	F/8 (sometimes F/11, more rarely F/4)	
Anastigmat	Varies greatly. Seldom smaller than F/6.8 or larger than F/4	
Soft focus	F/16	F/6 for single lenses and F/4 for doublets

[9] The apparent anomaly of the single achromatic working at a smaller aperture than the less fully corrected single meniscus is explained by the fact that the former lens, when supplied for pictorial work, is not designed to give as much diffusion as the latter.

Focal Length and Perspective.—We may now take up the question of the proper focal length of the lens, from the point of view of the artist, and, as stated in Chapter I, it will almost invariably be found that when a lens is furnished with the camera it is of too short a focal length to be desirable for pictorial work. It is generally said that a long focus lens gives better perspective than one of short focal length, but this is not quite correct, since the long focus lens merely forces the camera farther from the object in order to get a given size of image, and perspective depends on the relative distances between the planes of the

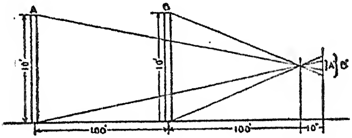


Fig. 25.

object and the camera. In Figure 25 suppose A and B to be two posts, each ten feet high, the distance between A and B and between B and the camera being one hundred feet. Suppose we have on the camera a lens of ten inches focus, then a simple proportion gives the sizes of the images, A′ and B′, of the posts, to be

$$10'' : 100' :: B' : 10' \qquad \text{hence } B' = 1''$$
$$10'' : 200' :: A' : 10' \qquad \text{hence } A' = \tfrac{1}{2}''$$

That is, the image of A is one-half the size of the image of B. If, now, we use a twenty-inch lens, then in order that the image of B may be the same size as in the first case it will be necessary to set the camera up twice

as far from B, when the proportions become as follows (Figure 26):

20″ : 200′ : : B′ : 10′ hence B′ = 1″
20″ : 300′ : : A′ : 10′ hence A′ = 2/3″

That is, the image of A is two-thirds the size of that of B, and the perspective is more pleasing, being less abrupt, though it should be noted that the perspective in the first case is absolutely true, being what an observer would see if he stood one hundred feet from B. If, however, the ten-inch lens is set up two hundred feet from B the ratio of the two images will be the same

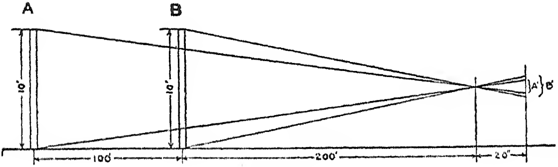


Fig. 26.

as if the twenty-inch lens were used, each image being half the size that it would be with the longer focus objective, and if the smaller negative be subsequently enlarged two diameters the final result will be the same in both cases, so far as perspective is concerned. It should be noted, however, that the use of a short focus lens and subsequent enlargement results in greater depth of field (and of focus) since, as stated above, the depth varies inversely as the focal length of the lens. Depth of focus is practically always desirable, but depth of field is not necessarily so, for it prevents the worker from emphasizing one particular plane by focus-

sing on it more sharply than on the others. This greater depth of field is one of the chief arguments brought forward by the advocates of the miniature cameras, but each worker must decide for himself whether or not the argument is valid in his own case.

If the lens is of too short focal length it will be difficult to keep far enough from the nearest object to insure pleasing perspective, since perspective is not very apparent on the ground glass, and the tendency is to approach near enough to get the principal object of the desired size. On the other hand, if the lens is of too great a focal length it will often be found difficult, by reason of the size of the studio or the configuration of the landscape, to get far enough away to include all that is wanted. The best focal length of lens to use for general purposes with any given size of plate is found by adding the lengths of two adjacent sides of the plate. Thus, for a 4×5 plate, a 9″ lens should be employed, for $6\frac{1}{2} \times 8\frac{1}{2}$, 15″, for 8×10, 18″, etc. This rule is purely empirical, but gives good general results, though it may sometimes be advisable to modify it somewhat. For example, if the worker is using a 4×5 plate, and wishes to do out-door portraiture or to select small landscape bits, a 12″ lens may be better, but if he is doing studio portraiture or wide landscapes, one of 8″ focal length may be preferable. Generally, however, a long focal length is to be preferred to a shorter one.

THE PIN-HOLE.—A device which is sometimes used in pictorial work, and which presents certain advantages over the lens, is the pin-hole. This is made by piercing

a hole from 1/50 to 1/20 inch in diameter in a thin plate, which is usually of metal, and placing this plate in the front of the camera, to project an image on the film. As stated above, every point of a luminous or reflecting body sends out rays in all directions, and if the pin-hole were of sufficiently small dimensions only one ray from each point of the object would reach the plate, as illustrated in Figure 27, thus forming an image of the point on the sensitive surface. Since, however, the pin-hole is of large dimensions as compared to a ray of light more than one ray from each point will

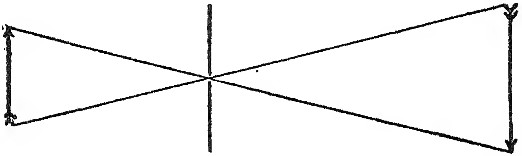


FIG. 27.

pass through, the practical result being a slight blurring of the image, which blurring may, however, be reduced to an amount inappreciable to the eye by sufficiently reducing the diameter of the hole. It should be noted, though, that if the diameter of the hole is less than 1/75 inch diffraction, or the bending of light rays in passing an edge, may cause the image to be somewhat lacking in definition, so it is not possible to secure absolutely sharp images by reducing the size of the aperture. Since the rays are not refracted, and since there are no reflecting surfaces, the pin-hole is entirely free from optical errors and from flare, and for the

same reason (that the rays travel in straight lines throughout) there is no focal point, the only effect of moving the plate nearer to or farther from the pin-hole being to alter the size of the image, and, of course, the amount included on the plate. Hence the pin-hole is equivalent in including power to a battery of lenses of all focal lengths. As a corollary, the pin-hole may in an emergency be used as an extreme wide-angle lens, having been successfully used with so short a bellows extension as 3½ inches on an 8×10 plate, the angle of view in that case being 142°. Of course, since the intensity of illumination falls off with the distance which the pin-hole (or lens) is from the plate, the light being spread over a greater area, a negative made in such extreme circumstances will show less exposure at the edges than at the center, but this can be equalized in printing.

Since light is propagated in straight lines outside as well as inside the camera, it follows that the pin-hole has infinite depth of field as well as of focus, all objects within the field of view being equally well defined. This may be an advantage or the reverse, the former because stopping down a soft focus lens to secure depth changes the quality of definition, the latter because it is sometimes desirable, as mentioned above, to emphasize one plane by focussing on it more sharply than on the others.

The advantages of the pin-hole, then, are infinite depth of field and of focus, and a very pleasing quality of definition, the amount of diffusion depending on the size of the hole. The disadvantages are the impossibility of accenting one plane at the expense of the others,

and the long exposures required. More or less complicated methods of calculating the exposure required with the pin-hole are given in various text-books, but the simplest is to divide the diameter of the hole in inches by the distance which it is from the plate, and to take this as the F number of the hole with that of bellows extension. (This, obviously, is the same method that is employed in finding the F value of a lens stop.) Thus with a hole of 1/20 inch diameter and an extension of 10 inches, the value would be $(1/20) \div 10 = F/200$. In these circumstances the exposure for a brightly lighted landscape at mid-day in June, using a fast plate, would be 3 seconds, whereas with a lens working at F/8 it would be 1/200 second. It will thus be seen that the use of a pin-hole precludes the photography of moving objects and even renders it impossible to do landscape work on a windy day, while it is entirely out of the question for general indoor portraiture. Within these limitations, however, it is a very useful instrument.

The illumination of the ground glass being very feeble when a pin-hole is employed, it is difficult to locate the image on the focussing screen with the hole to be used for exposure, and it is customary to surmount this difficulty by the use of an auxiliary hole of about 1/8 inch diameter, which gives more illumination and at the same time affords sufficient definition to permit of arranging the picture.

In describing the method of making a pin-hole the text-books usually give elaborate instructions for its manufacture, these directions looking toward an accurately gauged, sharp-edged hole. The writer finds, however, that for pictorial work it is sufficiently ac-

curate to punch a hole with a pin or needle in a piece of black paper such as plates are wrapped in, as the purpose of the more accurate method is to approximate lens definition, which is precisely what the artist wishes to avoid.

Discussion of the Soft Focus Lens.—It has been said that the primary value of the soft focus lens depends on the fact that it gives a quality of definition approximating that of the eye, but there are two other characteristics which go to make this type of objective desirable. The first is that by the use of an aperture

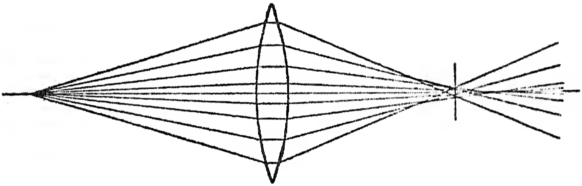


Fig. 28.

larger than normal it is possible to obtain greater diffusion, thus aiding in the suggestion of mystery, a suggestion which is of importance in any work of art, and the other is that such a lens, properly used, gives a vibrating quality of light which is closely akin to the psychic suggestion of sunlight. This latter characteristic requires further elucidation. In some of the earlier soft focus lenses diffusion was gained by means of spherical aberration, and if Figure 28 be examined it will be seen that with such a lens the image of a point of light will be formed partly by the axial and partly by the marginal

rays, and partly by those intermediate. Hence the image of such a point will be nearly a uniform disc of light, provided the plate be set in the plane of least diffusion, and the image of the object will be made up of a number of such discs, overlapping one another, thus causing diffusion. Most of the soft focus lenses now on the market, however, gain diffusion by means of chromatic aberration, and the effect is indicated in Figure 29. Here the light is analyzed, and if the plate is set in the focal plane of the violet rays, which have

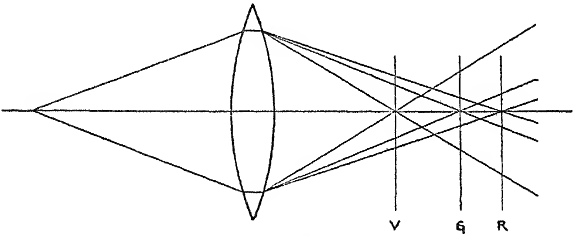


FIG. 29.

the most intense photographic effect, the image of a luminous point will be a spot of intense light surrounded by a halo due to the less actinic green rays, the effect due to the red rays being practically zero unless a panchromatic plate is used. Hence the image is made up of an infinite number of intensely illuminated spots surrounded by less intense, but moderately sharp-edged halos, and the effect is very different from that given by spherical aberration. Since the violet rays are the most active chemically and the yellow (green+red) are the most luminous to the eye, it follows that if the

plate be set at the visual focus the point will be due to the yellow rays and will be faint, whereas the halo, being due to the violet rays (which will be out of focus), will be intense, great diffusion resulting. If, on the other hand, the plate be set at the focus of the violet rays, diffusion will be least, the halo being caused by the green rays. A rough empirical rule for obtaining the best definition at a given aperture with a soft focus lens is to focus as accurately as possible on the principal object and then move the ground glass nearer to the lens until the principal object just begins to be out of focus, making the exposure with the plate in this position.

When using a lens having chromatic aberration a quality of definition identical with that seen on the ground glass may be secured by using a fully correcting ray-filter and focussing and exposing with it in position, since the ray-filter absorbs the ultra-violet and the superfluous violet rays, causing the residual color sensitiveness of the plate to coincide with that of the eye, and, of course, bringing the visual and the chemical foci into the same plane. The use of a ray-filter evidently presupposes the use of a color-sensitive plate.

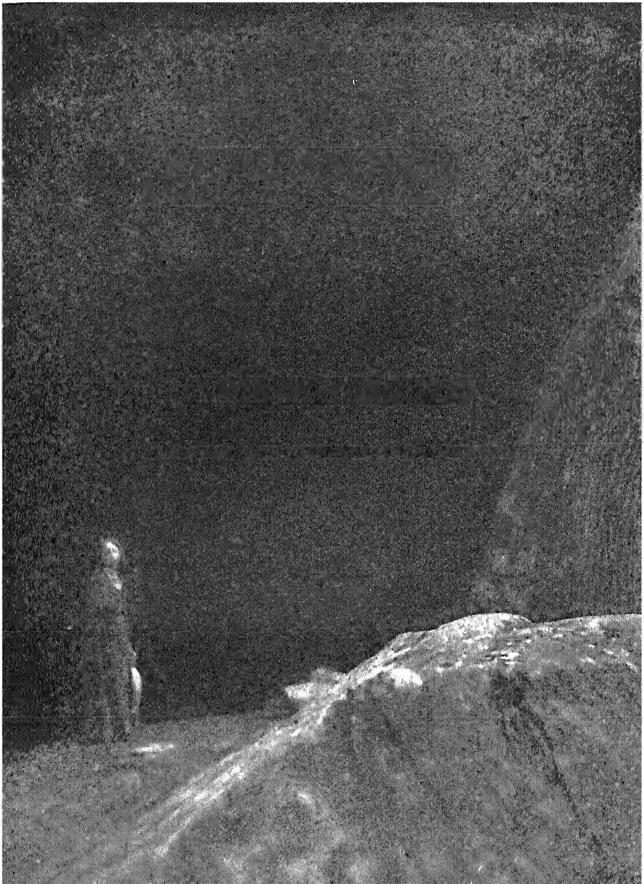
It is often stated that the same result may be secured by making an enlargement, using a soft focus lens for projection, as would be obtained if the original negative were made with a lens of this type, but this is not quite correct. In the first place, if a soft focus lens is used originally the plane focussed on is the sharpest, diffusion increasing progressively toward the distance, whereas if such a lens is used for enlarging both image and object are flat planes, so that diffusion

is uniform throughout the enlargement, regardless of the planes in which the various portions of the picture lie. In the second place, the halo which is found in the image given by a soft focus lens consists of a breaking of light into the dark spaces, so that if an enlargement is made on bromide paper from a negative, in which the lights are represented by dense spaces and the shadows by more translucent ones, the finished print will show a dark halo surrounding the shadows and extending into the lights, the effect being very unpleasant, and not true to the manner in which the eye perceives objects. If an enlarged negative be made with a soft focus lens from a transparency this effect will of course be as it should.

Since most of the soft focus lenses on the market are of the single type, few of them being rectilinear, it follows that they cannot, in general, be used for architectural work as such with entire satisfaction. It has been pointed out, however, that if the diaphragm is between the lens and the object distortion is barrel shaped, whereas if it is between the lens and the image distortion is of the pin-cushion type, and this suggests a method whereby such lenses may be used for architectural work without representing straight lines as bowed. If an enlargement be made from the original negative, using the same lens as was employed for making the negative, and taking care to place the diaphragm between the lens and the enlargement, the pin-cushion distortion in the enlargement will correct the barrel-shaped distortion in the negative, and the final result will be rectilinear. The introduction of additional diffusion in enlarging may be prevented by

stopping the lens down, since changing the size of the aperture does not affect distortion. This works well in practice, the results being all that could be desired.

Generally speaking, the soft focus lens is faster at a given aperture than the more fully corrected one, for, although all lenses of the same aperture have theoretically the same speed, an anastigmat or rectilinear usually has a greater thickness of glass than the soft focus objective, and the absorption of light in the glass may operate to make the corrected objective much slower—25 or 30 per cent. in extreme cases—than the simpler lens.



CHAPTER III

PLATES—FILMS—RAY-FILTERS

THE SPECTRUM.—It has already been explained that white light consists of ether vibrations of different wave lengths, the visible portion of the spectrum consisting of wave lengths from 4000 to 7000 A. U. In addition, there are known to exist waves of much less and much greater wave length, the former being known as ultra-violet and the latter as infra-red. The infra-red rays manifest themselves as heat and as Hertzian waves, and are of no great importance in photography, whereas the ultra-violet have a marked chemical (photographic) action, and are extremely important. If a beam of white light be analyzed by means of a diffraction grating it will appear as an elongated band of different colors, as shown in Figure 30, where the numbers indicate the wave lengths.

Visual Luminosity.—It will be found that the visual luminosity, that is, the intensity to the eye, of these colors varies, the yellow being the most intense, while the effect falls off toward both ends of the spectrum, so that if we plot a curve in which vertical distances represent visual luminosities it will appear as in Figure 31.

Ordinary Plate.—Since natural objects appear colored by reason of the fact that they absorb all light except that of a certain wave length (the wave length which gives rise to that particular color sensation) it

will be apparent that if they are to be represented by photography in their correct values, that is, relative luminosities in monochrome, the sensitiveness of the plate to light of the different wave lengths should be the same as that of the eye, but this is very far from being the case, for if the spectrum be photographed on an ordinary (non-orthochromatic) plate and the result plotted, the curve will have the form shown in Figure

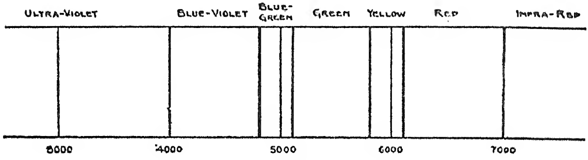


FIG. 30.

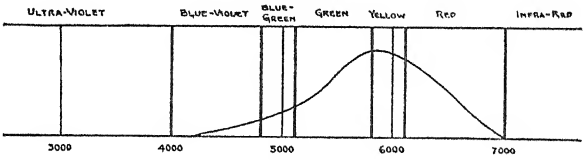


FIG. 31.

32. That is, the plate is sensitive to the ultra-violet, which is entirely invisible to the eye, has its maximum sensitiveness in the violet, to which the eye is comparatively insensitive, is only slightly sensitive to the green, and is totally insensitive to yellow and red.[1]

[1] A yellow or red object may, it is true, be photographed, by reason of the fact that a small percentage of white light is reflected unchanged from the surface of the object, but, though red or yellow is not rendered as absolutely black, as would be the case if a pure spectrum were photographed, it will still be reproduced as much too dark.

Orthochromatic Plate.—It is possible, by adding certain dyes to the emulsion, either at the time of manufacture or by bathing the plate afterward, to extend the sensitiveness somewhat, producing what is known as an orthochromatic ("right-colored") or isochromatic ("equally-colored") plate, and the color-sensitiveness curve of such a plate is shown in Figure 33. It will be seen that this plate is sensitive to green and

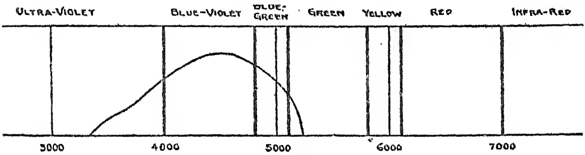


FIG. 32.

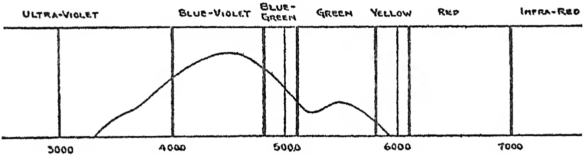


FIG. 33.

yellow in addition to the ultra-violet, violet, and blue-green, but still remains insensitive to red, and is but slightly sensitive to yellow, while retaining the ultra-violet sensitiveness.

Panchromatic Plate.—Certain other dyes, if added to the emulsion, render it sensitive to all visible light, and such plates are called panchromatic ("all-colored") trichromatic ("three-colored") or spectrum plates, the color-sensitiveness curve of such emulsions being shown

in Figure 34. It will be seen from the preceding diagrams that all plates, whether ordinary, orthochromatic, or panchromatic, are excessively sensitive to violet, which is dark to the eye, and to ultra-violet, which is totally invisible, and in order to correct this faulty sensitiveness it is necessary to employ a device known as a ray-filter or ray-screen, but before discussing the filter we will first consider the effect of photographing without it.

Anti-Screen Plate.—There is another type of orthochromatic plate, known as the "anti-screen" or "non-

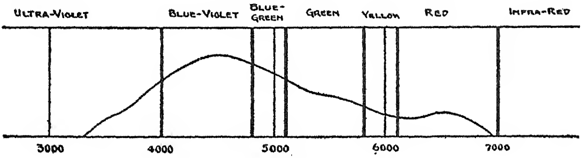


FIG. 34.

filter," in which additional dyes beyond those required for orthochromatizing have been added to the emulsion, and this plate is widely advertised as giving correct values without a filter, but, as will be seen later, such claims are without practical foundation, this plate offering no advantages over the orthochromatic so far as actual work is concerned, whatever improvement of color rendering may be shown in the laboratory, so it will not be considered separately.

Color-Sensitiveness Percentages.—In "Orthochromatic Filters" Dr. C. E. K. Mees gives the following table of the sensitiveness percentages of different types of plate:

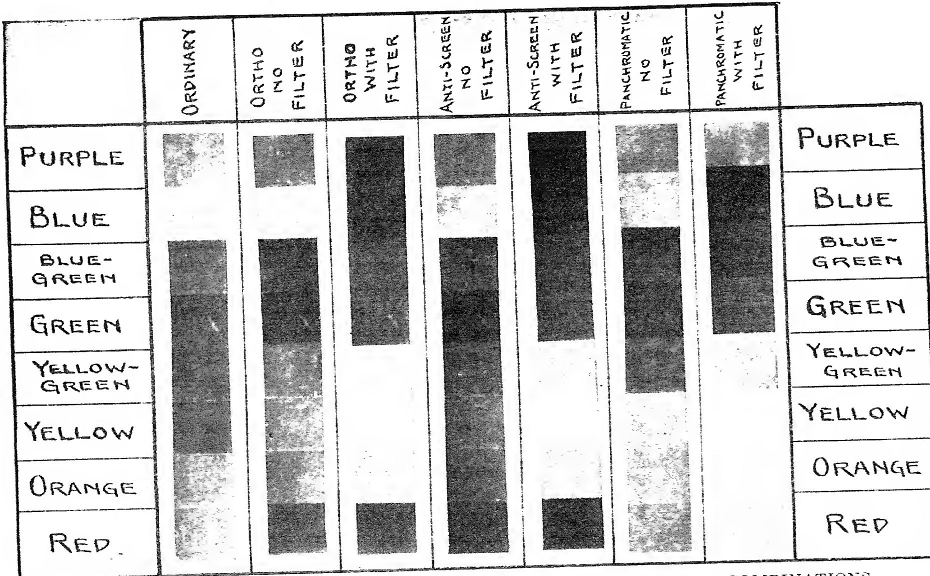


FIG. 35.—COPIES OF COLOR CHART WITH VARIOUS PLATE AND FILTER COMBINATIONS

Type of Emulsion	Ultra-Violet and Violet Sensitiveness	Color Sensitiveness (Green, Yellow and Red)
Orthochromatic........	95 to 98 per cent.	2 to 5 per cent.
Anti-Screen............	90 to 94 per cent.	6 to 10 per cent.
Panchromatic..........	82 per cent.	18 per cent.

To these we may add

Ordinary...............	100 per cent.	0 per cent.

for, although yellow and red will register on an ordinary plate if sufficient exposure be given, so long a time will be required that the other colors will be tremendously over-exposed.

TEST CHART.—One of the problems set by the writer for his students is the photographing of a test chart, so as to show practically the rendering of colors by different combinations of plates and filters, and a reproduction of the result is given in Figure 35, the photographs having been made by Mr. W. R. Latimer, class of 1915. The chart consists of a scale of five grays, with the colors violet, blue, blue-green, green, yellow-green, yellow, orange, and red, and it was photographed on an ordinary plate; on an orthochromatic, with and without a filter; on an anti-screen, with and without a filter; and on a panchromatic, with and without a filter, exposure and development being adjusted so that the scale of grays was rendered alike in all the prints. The panchromatic plate with the filter gave a correct rendering of the relative brightness of the different colors, and an examination of the figure will show to what extent the rendering of the other plates is faulty. It should be borne in mind that this test is more favorable to the ordinary, orthochromatic, and anti-screen plates than would be the case if it had been made with a spectroscope, since all the colors of the chart reflect

some white light, and the conditions are therefore more nearly those of actual practice.

PHOTOGRAPHING WITHOUT A RAY-FILTER.—When white light, that is, light containing all wave lengths, such as ordinary sunlight, falls on any natural object a portion is reflected unchanged from the surface, part is absorbed and quenched, and the remainder penetrates a short distance below the surface and is then reflected, the last portion being that which gives the object its color. It will be apparent that when this part is of a wave length to which the plate is insensitive the object is photographed entirely by that portion of the superficially reflected white light to which the plate is sensitive, and, the violet sensitiveness of the plate being so far in excess of the color sensitiveness, this is what practically always occurs unless a filter is used.[2] The practical results of this fact will be considered so far as landscape and portraiture are concerned, since if the fundamental principles are grasped they may be applied to architecture, genre, and other forms of work by anyone.

In landscape, assuming a sunny day, we find the sky to be a very intense blue, sunlit foliage a yellow-green, and foliage in shadow to be a blue-green, the last-named being illuminated entirely by reflected light from the sky. Hence we may expect the sky to photograph as very much lighter than it should, and, in fact, its actinic value is so nearly that of white that light clouds will be entirely lost, so far as printing value is

[2] Early in the morning and late in the afternoon the sun's rays pass through a stratum of relatively dense air carrying a higher percentage of moisture than that through which they pass near the middle of the day, and this air may act to some extent as a ray-filter.

concerned, though they may sometimes be distinguished in the negative. Foliage in shadow will photograph about as it should, the blue component of its illumination balancing to a great extent its local color, but foliage in sunlight will be darker than should be the case. Hence the foreground will be flat and lacking in contrast, the sky will be far too light, and clouds will not be retained unless they are very heavy, even heavy clouds being incorrectly rendered. In addition, ultra-violet light is markedly scattered by traces of moisture in the air, so that the middle distance and the distance will be too light in value. If, however, a suitable ray-filter is used and exposure and development are approximately correct, the values throughout will be rendered exactly as they appear to the eye, and it may be noted that since there is seldom any great amount of red in a landscape an orthochromatic plate is, generally speaking, as good as a panchromatic for this purpose, though if the ray-filter is to be omitted a panchromatic plate should be used, on account of its greater color sensitiveness.

In portraiture, however, the case is somewhat different, and here the panchromatic plate is invariably superior to any other, for, though falsification of values is sometimes desirable in landscape, for pictorial reasons, correct rendering is always desirable in portraiture. It is of course obvious that when it is said that the panchromatic plate is invariably superior to any other it is assumed that the photograph is to be made by white light or by some illumination containing a suitable proportion of yellow and red, for, naturally, if the mercury vapor arc is employed, a color sensitive plate

presents no advantages over an ordinary, the light in question containing no rays except ultra-violet and violet. However, it is assumed that the reader knows better than to expect a correct rendering of colored objects by monochromatic light, since it makes no difference whether the plate is color blind or the object reflects no colored light. The skin of a healthy Caucasian is distinctly yellow, with an element of red in lips and cheeks, hair usually tends to warm brown, though in some individuals it may be yellow or red, eyes are usually of a bluish-gray, though sometimes brown, and skin blemishes are yellow or reddish. Wrinkles have a reddish tendency, due to small capillaries lying near the surface, and the faint lines under the eyes are purplish in hue. Hence we may expect an ordinary or orthochromatic plate to render the skin, hair, lips, skin blemishes, wrinkles, and lines under the eyes as too dark, and the eyes themselves as either too light or too dark. In addition, since the shadows of the face are usually of a different color than the lights, being illuminated by reflected light, it follows that the planes will be falsified, and this faulty rendering of planes may completely change the expression of the face. A comparison of the rendering of the ordinary and the panchromatic plates is given in Figure 36, which was made in an ordinary studio, A having been made on an ordinary plate, and B on a panchromatic plate with a ray-filter. No retouching or modifying of any sort has been done on either of these negatives or prints, and attention should be called to the fact that B is an exact rendering of the sitter's appearance. No ordinary or even orthochromatic plate can render

FIG. 36A.—TAKEN ON ORDINARY PLATE

FIG. 36B.—TAKEN ON PANCHROMATIC PLATE WITH FULLY CORRECTING FILTER

correctly a subject containing so much yellow and red as the face, even with a ray-filter, and if true values are to be obtained in portraiture a panchromatic plate and filter are absolutely necessary. It is proof of the remarkable complaisance and equally remarkable lack of observation on the part of the public that portraits made on non-color-sensitive plates have been and still are being accepted by the sitters. In fact, it is doubtful if one-tenth of one per cent. of the professional portrait photographers in this country at the present time use panchromatic plates in regular studio work, whereas it may safely be said that if they realized the advantages of such emulsions all except the very lowest class would at once discard the ordinary and even the orthochromatic plate.

The Ray-Filter.—From what has been said it is apparent that in photographing on an ordinary, orthochromatic or anti-screen plate we are photographing practically entirely by ultra-violet and violet light, and even if a panchromatic plate be used this is to all intents and purposes the case, so that it is only in exceptional circumstances that the values can be rendered as they appear to the eye. If, however, some means be employed to subdue the excessive effect of the ultra-violet and violet rays, as well as a portion of the green, thus allowing the yellow and red opportunity to act on the emulsion before the effect of the other rays has become excessive, we can obtain correct values. Such a means is the ray-filter, which consists of a sheet of suitably dyed gelatine cemented between two pieces of glass and arranged so that it may be interposed between the plate and the object photo-

graphed, usually either immediately in front of the lens or immediately behind it. Filters are of two sorts, corrective and selective, the former having its absorption of light so adjusted that the sensitiveness curve of the plate when used with the filter corresponds to that of the eye (except, of course, that the orthochromatic plate has no red sensitiveness), whereas selective filters are so adjusted as to pass only a certain portion of the rays, thus emphasizing one region of the spectrum at the expense of the remainder. For instance, a red filter such as is used in three-color work transmits only red rays, absorbing the ultra-violet, violet, green, and part (the green component) of the yellow. Hence, if objects be photographed through such a filter any red portions will appear bright, since the light from these acts on the plate, all other colors seeming excessively dark. Selective filters are of value, generally speaking, only to process, commercial, and scientific workers, so will not be discussed here, readers who are interested being referred to the books by Dr. Mees, of the Eastman Kodak Company, and to the publications of the G. Cramer Dry Plate Company.

There are many different makes of filter on the market, some of them valuable and others worse than useless, for it is quite possible to over-correct a filter, that is, to give it an excessive absorption in one region of the spectrum, say the violet and green, so that yellow and red, when photographed through the filter, will appear too light as compared to the other colors. Furthermore, since not all makes of plate of one type have the same color-sensitiveness (not being sensitized with the same dyes) and since a panchromatic plate

may require an entirely different absorption from an orthochromatic, it is strongly recommended that the worker either obtain his ray-filter from the manufacturers of the plate with which it is to be used or else make careful tests on a color chart. Attention should be drawn to the fact that even the use of a panchromatic plate and an adjusted filter will not necessarily insure correct color rendering, since incorrect exposure will result in rendering some colors as too dark or too light, though there is considerable latitude in this respect, owing to the accommodation of the eye.

Some persons object to the use of a ray-filter on the ground that it prolongs exposure unduly, but this is not the case. Of course, it necessitates somewhat longer exposures, since some of the light which would otherwise act on the plate is absorbed by the filter, but filters may be obtained which give partial correction, with a decided improvement in color rendering, and require only twice the exposure necessary for the unscreened plate, while filters are to be had which give full correction and call for a multiplying factor of only five, this being a great improvement on the old ones, with some of which the factor was as high as eighteen, that is, the exposure with the filter was eighteen times that without. It may be said that if a filter requires more than five times the exposure which would be necessary without it, that filter is either over-corrected or is inefficient, though this must be understood as applying only to corrective filters; selective filters often necessarily require more increase of exposure than this, as will be realized after brief reflection. That a factor of five does not necessitate unduly long exposures may

be judged from the fact that the writer has made fully exposed negatives in a moderately well-lighted room at 11.00 A. M. in May with an exposure of 1/5 second, using a lens working at F/5.6 and a fast panchromatic plate. Had the filter been used this would have meant an exposure of one second, which is quite within reason for practically all purposes. So far as landscape is concerned, the writer has never had to discard the filter on account of time of exposure except when working by moonlight. Practically all the writer's negatives are made with a fully correcting filter, the screen being discarded only when falsification of values is desired, such as exaggeration of atmospheric perspective, or when photographing children indoors with poor light conditions. The matter of exaggeration of atmospheric perspective may require some further elucidation, and it will be remembered that mention has been made of the fact that ultra-violet light is strongly scattered by traces of moisture in the air. It is well known that on a misty day the distance appears much higher in value than when the air is clear, this being due to the fact that the particles of water vapor reflect light back to the eye, without permitting it to reach the objects included in the landscape, thus giving the appearance of a veil drawn over the distance. This effect is observable in a lesser degree at all times, and furnishes one of the means whereby we estimate distance, whence the term atmospheric perspective. Ultra-violet light is scattered more strongly by mist than the rays included in the visible portion of the spectrum, and, since ultra-violet light affects the plate more strongly than the rays of a greater wave length,

it follows that when any moisture is present in the air the distance will appear lighter to the plate than to the eye. If a suitable ray-filter is used, however, the effect on the plate will be identical with the visual effect. Still, judgment must be used, as a single instance from the writer's experience will show. A photograph was made of a winding path in a park, a figure being posed in the middle distance, and practically no sky being included in the view. The path was of a bluish-gray gravel, and was bordered by green lawns, the light values of gravel and grass being nearly the same, though, by reason of the difference in color, the path was clearly visible to the eye. Had a filter been employed, it would have been almost impossible to distinguish the path from the lawn in the negative, but the filter was omitted, and the path photographed much lighter than the grass. The values in the print were of course untrue to nature, but the pictorial result was good.

The writer strongly recommends that the worker select one plate and adhere to it throughout, and advises a fast panchromatic plate, since this will do all that any other will, and a great deal that no other will accomplish, this advice being, of course, based on the supposition that the photographer intends to do various kinds of work. As explained above, if landscape work only is to be done, an orthochromatic emulsion is practically as good as the panchromatic. It is true that a panchromatic plate, being sensitive to all visible light, cannot conveniently be developed by inspection, but this fact involves no hardship to one who employs tank development, which is recommended in any case.

Those workers who regard development as a form of recreation will object to the use of the tank, and as a consequence debar themselves from enjoying the advantages of panchromatic plates, but those who, like the writer, consider the negative merely as a means to an end, are free to use fully color-sensitive emulsions, and will find that they present many advantages over others, not least among them being the elimination of retouching, since freckles and wrinkles are not exaggerated, and the values—and consequently the planes—are rendered precisely as they appear to the eye.

Halation.—It will in practically all cases be found advantageous to use a plate which is halation-proof, such a one being almost imperative in landscape work, so we will next consider the question of halation and the various methods of preventing it. It has already been stated that when a ray of light passes from one medium to another of different refractive index there is some reflection from the surface where the two mediums join, and it is this fact which is responsible for halation, as will be understood on referring to Figure 37, which represents a sectional view of a dry plate with a ray of light incident on it from the lens. If the light is allowed to act for a sufficiently long time the inertia of the emulsion is completely overcome and the light passes through it to the glass, part of it being reflected back in the manner shown, to a path some distance from its original path through the film, where it produces a secondary effect on the emulsion. This manifestation is apparent whenever a plate not especially prepared is used to photograph a subject having strong contrasts, such as a landscape with sky, an

interior with windows, or a white dress against a dark background, and it shows itself in the form of a halo spreading from the light spaces into the dark ones. It may be avoided to some extent by special methods of development or be corrected by after-treatment of the negative, but the simplest means is to use a non-halation

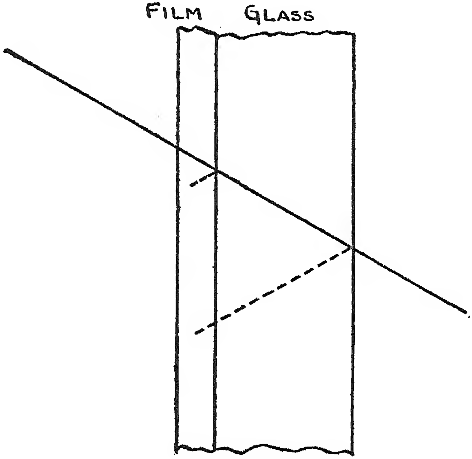


FIG. 37.

plate. There are several ways of preparing such plates. (1) Double-coating, that is, placing a slow emulsion on the glass and a fast one on that, so that the shadows will be recorded on the fast emulsion before the lights have had time to overcome the inertia of the slow one. This method is the usual one in America, the Standard Orthonon, the Seed and Hammer Non-Halation, and

the Cramer Double-Coated being typical plates of this class. (2) Using the same emulsion throughout but making it very thick, so that it has great inertia to the lights but little to the shadows. The writer knows of but two manufacturers who employ this method, the G. Cramer Dry Plate Company, whose Portrait Isonon and Commercial Isonon plates are of this class, and the Central Dry Plate Company. Methods (1) and (2) possess the advantage of giving plates with great latitude, that is, if the subject be a normal one the exposure may be many times normal without causing the negative to show signs of over-exposure. (3) Backing. That is, placing an opaque or non-actinic film of about the same refractive index as glass in optical contact with the back of the plate, so that any light which reaches the back of the glass is absorbed by the backing. This method is the one most common in England, the Wratten Panchromatic plate being of this type. Backing is as efficient in preventing halation as double coating, but the latitude is of course no greater than that of an unbacked plate. (4) Coating the emulsion on a thin support, such as a celluloid film or a sheet of paper. In this case the reflected light returns into the emulsion so near its original path that halation is not apparent. (5) Placing between the glass and the emulsion a film of some non-actinic dye, which is discharged either in developing or in fixing. Some French and German manufacturers use this method, but it is not customary in either America or England, though quite as efficient as any other means. (6) Incorporating hydrazine with the emulsion. There is on the market a non-halation plate made in this fash-

ion, and it is extremely efficient. (7) In addition to the above, it may be observed that halation can often be diminished or prevented by exposing with the glass side toward the lens, etc. If this method is adopted it is advisable to clean the glass side of the plate thoroughly before placing it in the holder.

In connection with backing, two points should be noted. First, that the backing must have approximately the same refractive index as glass and must be in optical contact with it, so that the plan of lining the plate-holders with black paper or cloth, as advised by some writers, is of no value, and, second, that a red backing, though useful with ordinary or orthochromatic plates, is not recommended for use with panchromatic emulsions, in which case the backing should be black. If the worker wishes to back his own plates he may do so by clamping them in a printing-frame, glass side out, and brushing with

Mucilage	1 ounce
Caramel	1 ounce
Burnt Sienna, ground in water	2 ounces

Mix and add

Alcohol	2 ounces

This formula is taken from the British Journal Almanac, and is obviously intended for ordinary or orthochromatic plates, but there seems to be no reason why lampblack or ivory black should not be substituted for the burnt sienna, thus rendering it suitable for panchromatic plates. After brushing, the plates should be allowed to dry in the dark. If preferred, the plates may be clamped film to film in pairs, and dipped into the backing mixture.

Bromide Paper.—It is quite possible to use bromide paper instead of plates for making negatives direct in the camera, the advantages being lightness, freedom from danger of breakage, compactness in storing, freedom from halation, ease of modifying the negatives with pencil or stump, and the fact that the grain of the paper imparts an interesting texture to the print. The disadvantages are that bromide paper is obtainable only in ordinary emulsions, that it requires slightly longer to print, and that the speed is from 1/20 to 1/100 that of the average plate. It is apparent that the worker who desires to use this method should choose a fast emulsion, coated on a thin, smooth stock, and it is further to be observed that if the negatives are smaller than 6½×8½ the grain of the paper is likely to become unpleasantly apparent. Nevertheless, within these limitations paper negatives are capable of giving good results, as is shown by the fact that all of D. O. Hill's magnificent portraits were printed from such negatives, and by the fact that many of the best workers use bromide paper exclusively for enlarged negatives, this fact being considered further in Chapter VII.

Plates or Films.—At the time this book was written, manufacturing conditions were such that the author felt a decided preference for plates over any of the films then on the market. Of recent years, however, great improvements have been made in the films available, and it seems well to reverse the earlier decision. These improvements include:

(1) Double-coated orthochromatic film for use in roll-film cameras and in film packs.

(2) Double-coated panchromatic cut film for use in cameras employing holders or magazines.

(3) Films coated with special emulsions for various technical purposes.

(4) A "safety base," that is, an almost non-inflammable slow-burning celluloid support.

From the above it follows that films are now photographically equal to plates, with the advantages of lightness and compactness; and with modern methods of handling are quite as convenient to manipulate in the absolute darkness required by fast panchromatic emulsions.

Plates seem to keep a little better in extreme tropical climates, and of course the fire hazard involved in storing them is not only very slight, as with films, but is absolutely nonexistent. On the whole, though, the author feels that the advantages of lightness and compactness outweigh these slight disadvantages, and he now prefers films to plates.

Certain other items of interest in connection with the newer films are worth noting, the most conspicuous being the great improvements in speed in both panchromatic and orthochromatic emulsions, especially to artificial light. This increased speed in the former type of emulsion is so great that the author has secured satisfactory portraits at a lens aperture of F/5.5 with one second exposure by the light of a single 60-watt Mazda bulb; and five seconds by ordinary stage lighting gave serious over-exposure.

In order to render them absolutely non-halation, certain films are backed with a non-actinic dye which is discharged in the course of development. This idea

is not new, but it is only recently that it has come into general use.

Methods of desensitizing have been worked out, whereby the exposed emulsion is rendered practically insensitive through immersion in a dye bath before development, or through the addition of a dye to the developer, so that development by inspection may be carried out in a strong light. The author, however, has not experimented with this process, as he feels that tank development is in any case preferable to the older method.

CHAPTER IV

EXPOSURE AND DEVELOPMENT

Characteristic Curve of Plate.—If successive portions of a dry plate be given progressively increasing exposures to a standard illumination, and the plate be developed in any standard developer, the densities of the different portions being measured (after the plate is fixed, washed, and dried) by means of a photometer, a curve may be plotted in which abscissæ represent light-action and ordinates densities, and it will be found that the form of this curve is constant for every make and type of plate, though the actual dimensions may vary. This curve is known as the characteristic curve of the plate, and is due to the classical investigations of Messrs. Hurter and Driffield, two English scientists who made a series of experiments with regard to exposure and development, some years ago. This curve is shown in Figure 38, and it will be seen that it may be divided into four portions, (a) in which density increases relatively more rapidly than light-action, (b) in which density and light-action increase in the same ratio, (c) in which density increases relatively less rapidly than light-action, and (d) in which density decreases as light-action increases. The first corresponds to under-exposure, the second to normal exposure, the third to over-exposure, and the fourth to reversal, in which the plate develops as a positive instead of a negative, this last-named phenomenon being of laboratory interest only.

In order to make the meaning of this curve clear to the non-scientific reader, let us suppose that we wish to photograph three objects, and to reproduce them in their proper relative values, one of the objects being white, one black, and the third of a gray which is midway between white and black. Obviously, the gray object should have, in the negative, such density that its image, in the print, will have a value midway between that of the white and that of the black objects, and this will be the case if the exposure was what we

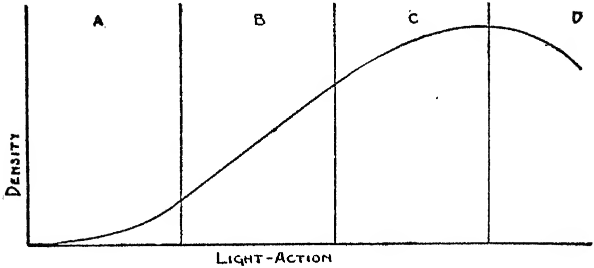


Fig. 38.

call normal. If, however, the exposure was insufficient, the density of the gray object will be nearer that of the black than that of the white, all the values, of course, being incorrectly rendered. On the other hand, if the exposure was excessive the density of the gray object will be nearer that of the white than that of the black, the values being as faulty as in the other case, though in a different manner. This may be understood by reference to Figure 39, in which (A) represents under-

exposure, (B) normal, and (C) over-exposure. These facts are usually expressed by saying that under-exposure flattens the shadows, giving a thin negative lacking in shadow detail, and that over-exposure flattens the lights, giving a thick negative which lacks brilliance. Messrs. Hurter and Driffield also found that this internal relationship of values cannot be altered by any modifications of development or by changes in the composition of the developer, thus disproving the popular idea that errors of exposure may be

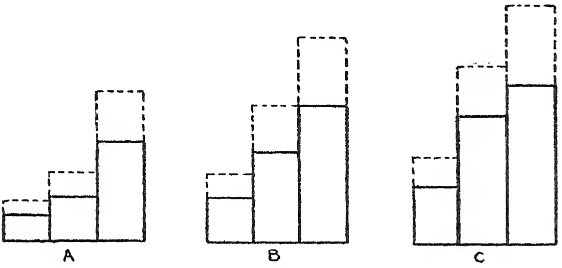


Fig. 39.

corrected in development. Curiously enough, this false idea, which is based on empirical and unscientific observation, still persists to some extent, and we find writers, even at the present day, advocating the addition of restrainer in case of over-exposure, and of alkali in under-exposure. It is true that the contrast of the negative may be increased by prolonging development or decreased by giving shorter development than normal, but the internal relationship (except in one special case, which will be discussed later) is fixed once for all

by the exposure. In Figure 39 the dotted lines represent the densities of the various gradations with prolonged development.

HURTER AND DRIFFIELD'S LAW.—These facts may be expressed in the form of a law, as follows:

Relative contrast is a function of exposure.

Actual contrast is a function of development.

The term "actual contrast" of course refers to the separation between the extremes of the negative. That is, to refer again to the illustration of the three objects, short development may result in rendering the black object as a dark gray and the white object as a light gray, whereas excessive development may result in extending the scale of the negative beyond the capacity of any printing paper to render, but the relation of white, gray and black is not changed by any variations in development.

FAILURE OF HURTER AND DRIFFIELD'S LAW.—There is one case in which this law fails; namely, in the case of relatively brief development in a very dilute solution. This exception to the law was noted by Messrs. Hurter and Driffield, and is explicable in the following manner: When a plate is exposed on objects having a range of gradation from dark to light (as is always the case in pictorial work) the action of the light reflected from the lighter objects extends fairly deep into the film, whereas the light-action in the shadows may be chiefly on or near the surface. When a developer is applied to the plate the light-affected silver salt on the surface is readily reduced to the metallic state, but in order that the underlying portions may be developed it is necessary that the reducing agent penetrate deep into the

gelatine film. If the developer is very dilute a given volume of the solution carries but a small amount of reducing agent, and this readily becomes exhausted in acting on the silver salt. If the action is taking place near the surface of the film the exhausted developer may easily be got out of the film and replaced by fresh (by rocking the tray), whereas if it is going on deep within the film some time is required for the exhausted agent to be replaced, and all the while the reduction of the surface silver (that is, the shadows) is proceeding. Hence if development is arrested before all the light-affected silver salt has been reduced to the metallic state the shadows will have normal density but the lights will have less than they should, and the negative will have somewhat the appearance of over-exposure, though the variation from normal will be very slight. Therefore, in the case of known under-exposure the use of a very dilute developer will tend to produce better results than normal treatment. Of course, if a strong developer is used this flattening of the lights does not take place, since the reducing agent is not so readily exhausted within the film.

Treatment of Under- and Over-exposure.—Although nothing can be done to correct errors of exposure by modifying development, much can be done by after-treatment of the negative, but in order to get the full benefit of such treatment the development should be somewhat different from the normal. If under-exposure is discovered after development has commenced, the plate should be transferred to a very dilute developer and kept there until all possible shadow detail has appeared, or until the negative begins to show

fog, regardless of the quality of the lights, which, of course, will be far too dense when fixation is complete. The result will be a negative which will probably have a scale too great for any printing paper, but subsequent reduction with ammonium persulphate, which attacks the dense parts more than the thin, will give a negative approaching more nearly a correctly exposed one than any other treatment. If the plate shows over-exposure development should be prolonged in order to gain as much contrast as possible, the excessively dense negative being afterward reduced with Farmer's reducer, which attacks the shadows before the lights, thus getting more brilliance than would come from normal development.

Characteristics of Abnormal Negatives.—The writer has found that many persons, even some who have had considerable photographic experience, are unable to determine by inspection whether a negative is under-exposed or under-developed as well as whether it is over-exposed or over-developed, and it seems advisable to indicate the difference in appearance of these faults. An under-exposed negative will, as stated above, be thin all over—assuming that development has been normal—will be lacking in shadow detail, and will show excessive contrast between the lights and the shadows. Under-development will give a plate which will be thin, but will probably show some indications of shadow detail, and will have a normal range of gradation. Over-exposure results in a dense, flat negative, lacking in brilliance in the lights, whereas an over-developed plate, though dense all over, will have brilliance and contrast. Some little experience will be

LANDSCAPE
BY KARL STRUSS
From a Platinum Print

necessary before the worker can distinguish readily between these failings, and it would be very profitable for a young photographer to make a series of experiments in which under-, normal, and over-exposure are combined with under-, normal, and over-development.

Function and Composition of the Developer.—Although the action of the light is to effect a change in the sensitive salt contained in the film, no change is visible until the plate has been treated with a developer, unless, indeed, the exposure be tremendously excessive. The function of the developer is to reduce the light-affected salt to metallic silver, and the developing solution generally consists of water, a reducing agent, a preservative, to keep the reducing agent from being oxidized too rapidly by the oxygen in the water, and an alkali, the precise effect of this latter ingredient not being accurately known. Some reducing agents, notably amidol, do not require the addition of an alkali, but in general this ingredient is necessary. There are forty or fifty different reducing agents available, most of them derived from coal-tar, though some are obtained from nut-galls, lichens, sea-weed, or other vegetable substances, and one is inorganic. The preservative most in use is sodium sulphite, though citric acid, potassium metabisulphite, and other chemicals are sometimes employed. The most usual alkali is sodium carbonate, but caustic soda, caustic potash, and carbonate of potash are also used. Formulæ for different solutions will be given later, together with a brief discussion of the characteristics of the better-known reducing agents.

Methods of Development.—There are four methods of development, (a) by inspection, (b) factorial, (c) by time in a tray and (d) by time in a tank. In development by inspection the exposed plate is taken from the holder in the dark-room, immersed in a tray of developer, and rocked until the worker judges, from looking at the negative by transmitted light (non-actinic light, of course) that development has progressed far enough to give the desired quality of print. This is the most laborious, most uncertain, and least scientific method, besides being most likely to result in damage to the negative from scratches or fog, no dark-room light being absolutely safe. Nevertheless it is the method most in use, since it is the oldest, and most photographers, like other individuals, are reluctant to adopt new methods. In addition to the other reasons for discarding this form of development, we may note that if there is much work to be done a very noticeable reduction of the worker's vitality results from a prolonged stay in the dark-room, this reduction sometimes amounting to two or three per cent. in as many hours. Some photographers profess to enjoy dark-room work, and when this is the case all that can be said is that if the worker regards development as a form of amusement he should by all means develop by inspection; but those photographers who, like the writer, consider the negative merely as a means to an end—the print—will do well to adopt some other method.

The factorial method, worked out by Alfred Watkins, depends on the fact that for every reducing agent, irrespective of the concentration and composition of the developing solution, there is a definite ratio between

the time required for the plate to gain all the contrast possible in the given circumstances, and the time required for the image to make its appearance after immersion in the developer. This ratio is known as the factor, and there are but few exceptions to the rule stated, pyro and amidol being the best-known of the agents whose factor depends on the strength of the solution. Mr. Watkins has determined the factors for the reducing agents most in use, and gives the following table:

Adurol	5	Imogen sulphite	6
Amidol (2 grains per ounce)	18	Kachin	10
Azol	30	Mequin	12
Certinal	30	Metol	30
Diogen	12	Ortol	10
Edinol	20	Paramidophenol	16
Eikonogen	9	Pyrocatechin	10
Glycin-potash	12	Quinomet	30
Glycin-soda	8	Rodinal	30
Hydroquinone	5	Synthol	30

Pyro, no bromide.

Grains of pyro per ounce of solution	Factor
1	18
2	12
3	10
4	8
5	6½

Azol, certinal, citol, and rodinal are said to be the same product under different trade names, being a concentrated solution of paramidophenol with preservative and caustic alkali. It may be noted that in numerous other cases different names represent the same chemical. Thus, metol and elon are said to be identical except that the former is put out by Hauff and the latter by the Eastman Kodak Company. To employ the factorial method of development the factor to be

used in the specific case is first determined (using, of course, a smaller factor than the one given if less than maximum contrast is desired) and the plate is immersed in the solution in the dark-room, the tray being rocked and the plate watched until the image first begins to appear. The time required for this first appearance is multiplied by the factor chosen, and the plate is developed for the total time thus indicated. Of course, the tray may be covered during development, thus minimizing the risk of fog. To take a concrete example, suppose rodinal is being used and a soft negative is desired. The factor chosen would probably be about 20, depending on the contrast in the subject and the quality of the result to be obtained. Suppose the image to appear in 10 seconds, then the total time of development would be 200 seconds, and the plate would be developed for three minutes and twenty seconds from the first immersion, being fixed and washed at the expiration of the time, without the need for further examination. This method represents a great advance on the inspection method, and is strongly recommended to those workers who, developing only one or two plates at a time, do not care to use a tank.

In time development in a tray the plate is immersed in the developing solution and the tray rocked for a definite length of time, this time depending on the composition, strength, and temperature of the solution (since all developers act more rapidly at high temperatures than at low ones) and on the development speed of the plate, different makes of plate varying greatly in this respect. Only experience can determine how long

to develop in order to get the desired contrast, but this method is very convenient for those workers who are willing to make a few experiments with their customary brand of plate, in the event of there being only one or two plates to develop, and it is practically imperative with panchromatic plates. Obviously, there is no need of using a dark-room light when time development is employed, so that this forms a very desirable method when travelling, since any room can be used as a dark-room at night.

Tank development is the same as time development, except that a water-tight tank is used, a number of plates being placed in a rack in the tank, so that they are kept vertical, and that a weak developer is employed, with the result that development requires from fifteen minutes to an hour, depending on circumstances. Tank development is economical of time, since a dozen or more plates may be developed at once, obviates all danger of fog or scratching, and automatically gives the best quality of negative from any given subject and exposure, since slow development in a dilute solution is nearly always preferable to rapid development. Care must be taken to see that the tank is kept free from dirt or undesirable chemicals, and it should be of a type having a cover which locks on, so that the tank may be inverted at intervals, since if it remains always in one position the developer will settle, giving greater density at one end of the negatives than at the other. It is also well to have the tank so arranged that the developer may be poured in and out after the plates are in place, since in this case a dark-room is necessary only for loading the plates into the tank,

development and fixation being carried out in full daylight.

Characteristics of Various Developers.—Despite the claims of some manufacturers, there is no difference among the numerous reducing agents, so far as the power of giving density and detail are concerned or as regards inherent fog-producing tendency. There is, however, great difference in the speed of working, and in the manner of doing the work. It will be seen from the table on page 85 that reducing agents may be divided into two broad classes, those having short factors and those having long ones, and it has been found that the latter tend to bring out the image all over the plate early in the process, lights, half-tones, and shadows nearly simultaneously, the density growing subsequently, whereas the agents having short factors bring out the lights first, and after these have gained some density the half-tones appear, both lights and half-tones growing in density for some time, the shadows finally making their appearance. From this it will be seen that if a soft, fully detailed negative is desired it is best to choose a long-factor developer, such as rodinal or metol, whereas if considerable contrast is wanted a short-factor one, *e.g.*, strong pyro or hydroquinone, is to be preferred, so that, although a short-factor developer may be made to give a soft negative by development in a dilute solution, or a long factor agent may be made to give contrast by prolonged development in a concentrated solution, convenience dictates that the agent be chosen with regard to the work to be done. This relation between manner of working and length of factor seems to have no scientific basis, being purely

empirical, but it will be found generally true, the chief exception being eikonogen, which has a relatively short factor but tends to give soft negatives.

For the sake of convenience, the developer should be capable of being made up in the form of a concentrated solution, requiring only dilution with water to be ready for use, and should keep well when so made up. It should also work satisfactorily when used for several plates in succession, and if the used developer can be kept and employed on subsequent days this is an additional advantage. There are several agents which fulfil these requirements, and formulæ are given below.

Metol-Hydroquinone.

Water, distilled, warm	16 ounces
Metol	96 grains
Hydroquinone	384 grains

Dissolve and add

Sodium sulphite (anhydrous)	1310 grains

Stir, and when the sulphite is dissolved there will be a thick white precipitate.

Add

Caustic soda (pure stick)	256 grains

When the alkali is dissolved the solution will be clear. Filter into a bottle. For use take

Stock	1 ounce
Water	10 to 30 ounces.

Factor about 16.

Edinol.

Water, distilled, warm	14 ounces
Potassium metabisulphite	300 grains
Sodium carbonate (anhydrous)	800 grains

Grind these two salts together intimately in a mortar and dissolve a little at a time.

Add

Edinol	300 grains

When dissolved filter into a bottle. For use take

Stock	1 ounce
Water	10 to 30 ounces

Factor 20. Hot water must not be used or the metabisulphite will be decomposed.

Eikonogen cannot well be made up in the form of a concentrated solution, but it is an excellent developer, and a formula follows:

A.	Water, distilled	30 ounces
	Sodium sulphite (anhydrous)	480 grains
	Eikonogen	240 grains
B.	Water, distilled	30 ounces
	Sodium carbonate (anhydrous)	360 grains
	Use.	
	A	1 ounce
	B	1 ounce
	Water	0 to 1 ounce
	Factor 2.	

Rodinal is very convenient, being sold in the form of a concentrated solution, requiring only dilution for use.

Use	
Rodinal	1 ounce
Water	10 to 30 ounces
Factor 30.	

Rytol is also very convenient, and is especially recommended for use when travelling, since it is sold in the form of tablets, which are to be dissolved in water for use, hence it can do no damage if the bottle is accidentally broken.

Use	
Rytol, one pair of products	
Water	4 to 12 ounces
Factor 12 to 18.	

Practically all the desirable developers can be obtained in tablet form, but the writer prefers rytol, not because it is better than the others, but because it is cheaper than most. Pyro is a popular agent, but has many disadvantages as compared to the newer organic developers, in that it does not keep well in solution unless special precautions are taken, that it cannot be used repeatedly, and that it tends to stain plates and fingers

badly. The writer uses it only for tank development, when these objections disappear if the solution is made fresh at the time of use. Two formulæ follow:

Pyro for Wratten panchromatic plates (8×10 tank).

Tap water	150 ounces
Sodium sulphite (anhydrous)	405 grains
Sodium carbonate (anhydrous)	135 grains
Pyro	135 grains

Development time one-half to three-fourths that given on the speed card packed with plates.

Pyro for Eastman film.

Tap water	50 ounces
Sodium sulphite (anhydrous)	90 grains
Sodium carbonate (anhydrous)	60 grains
Pyro	30 grains

Development time 20 minutes at 65° Fahrenheit.

As stated above, all developers work more rapidly when warm than when cold, and the ideal temperature is 65° Fahrenheit, it being of especial importance to maintain a definite temperature when developing by time. Some agents, especially hydroquinone, work with impractical slowness at low temperatures, and if the solution goes above 70° Fahrenheit there is always danger of frilling; that is, loosening of the film from the glass. Therefore, a thermometer should be part of the equipment of every dark-room.

CHAPTER V

MISCELLANEOUS APPARATUS

Actinometers and Exposure Tables.—There are three methods of determining the correct exposure in any given circumstances: first, by past experience; second, by the use of an actinometer which measures the intensity of the light falling upon the subject; and third, by the use of an exposure table which gives the correct exposure for different subjects with different conditions of light, lens stop and plate speed. The first method is not recommended, since it requires considerable experience and is at best uncertain, even practised photographers often going astray. Either of the other methods is satisfactory, but must be used with judgment, since neither is absolutely accurate in all circumstances. There are two types of actinometer, the first depending, as in the instruments of Wynne and Watkins, on the time required for a piece of sensitive paper to darken to match a standard tint, the second, as in the case of the Heyde meter, depending on the progressive obscuring of shadow details as varying thicknesses of tinted glass are placed between the eye and the object to be photographed. Any of the instruments named will be found satisfactory for general use, but they will tend to call for unnecessarily long exposure when used in a weak light, such as that of late afternoon or indoors. There are a number of different exposure tables on the market, such as those given in the various photographic magazines, the

Harvey meter (which is really an exposure table) the Burroughs Wellcome note-book and others. The writer's experience shows that all of these are quite reliable, but indicates that the Burroughs Wellcome note-book is the most convenient form, this possessing not only completeness and accuracy combined with compactness, but also furnishing a space for recording data concerning exposures, such as the serial number of the negative, the kind of plate used, the lens aperture, the character of the light, the time of day and of year, and the exposure given. It is strongly recommended that this information be recorded with every exposure, at all events until the photographer has gained considerable experience, since reference to it from time to time will aid notably in developing the judgment. It will be found that exposure tables as well as actinometers fail in a weak light, but with exposure tables the failure is due to a tendency to indicate insufficient exposure and also to the fact that it is difficult to estimate visually the quality of the light when this is relatively weak; that is, although it is easy enough to see whether it is intense or slightly veiled, it is difficult to tell whether it should be classed as dull or very dull.

Shutters.—There are numerous types of shutter, each being especially adapted for some particular purpose, the simplest method of making an exposure being with the lens cap, which is perfectly satisfactory when exposures of less duration than a quarter of a second are not desired. The between-lens shutter is good for general purposes, but is not made for large lenses, and the cheaper grades cannot be depended on for accuracy

at the higher speeds, the variation from the marked speed being often 100 per cent. or more. The more expensive, as the Koilos, Compound, Goerz or Multi-speed, are usually fairly accurate, but any between-lens shutter is relatively inefficient at high speeds, owing to the fact that the lens is not working at full aperture during the entire time of exposure, since the leaves of the shutter require a perceptible interval to open and close. For rapid exposures the focal plane shutter will be found more efficient, since this consists of a strip of cloth having slits the full length of a plate and of varying width, operating immediately in front of the plate, so that the full aperture is available during the entire time of exposure. Different speeds are obtainable by varying the width of the slit or the tension of the spring or both, so that the curtain travels across the plate at varying rates of speed or permits the passage of only a narrow band of light during a given interval. The most desirable form of this type of shutter is the one in which the curtain consists of a long strip of cloth with different sized slits, rather than the one in which the width of the slit is variable, since the latter is more likely to get out of order and give a slit wider at one end than the other, thus giving more exposure to one side of the plate than to the other. The roller blind shutter resembles the focal plane type in that the exposure is made by the travel of a curtain having an opening in it, but it is usually placed immediately before or behind the lens instead of near the plate, and has but one slit (the width of which is equal to or exceeds the full aperture of the lens), the speeds being controlled entirely by the tension of the spring. This type of

shutter is fairly efficient and is simple and not likely to get out of order, but as sent out by the makers is not, as a rule, accurately marked for speed, wherefore the speeds should be tested if precision is desired. There are numerous forms of studio shutter, the chief desideratum in this instance being noiseless operation, and the best shutter of this form known to the writer is that in which the leaves of the shutter form the diaphragm of the lens, exposure being made by the opening and closing of these leaves. This shutter is relatively slow as compared to other types, for the most rapid exposure obtainable with it is about 1/8 second, whereas the between-lens shutter will give from 1/100 to 1/300 (the Multispeed is said to give 1/2000), the focal plane will give about 1/1000 and the roller blind about 1/75. Of course these high speeds are not necessary for indoor work, where an exposure of less than 1/8 second is practically never desired.

Other Apparatus.—Every worker will determine for himself what is required in the way of general apparatus, but a few suggestions may be given. As regards trays, those made of hard rubber are probably the best for general purposes, but are also the most expensive and are somewhat fragile. Porcelain and glass trays are also good, but are liable to be broken unless carefully handled. The porcelain-lined steel trays are not open to these objections and are very desirable, though it sometimes happens that the enamel is chipped off and the metal exposed, which of course interferes with their usefulness, since many solutions are injured by contact with the steel. In such a case a touch of asphaltum varnish will often repair the damage satis-

factorily. Japanned paper trays are good as well as cheap and are not readily broken, but the japan sometimes cracks, in which case the asphaltum varnish may be requisitioned. Japanned metal trays are not desirable, since the japan flakes off very readily.

Developing tanks should be of brass nickel-plated, in which case they may be used for fixing as well as developing, provided they are kept clean and acid hypo is not used, since the acid will attack the metal. Zinc developing tanks should not be employed, as these are attacked by plain hypo and can be used only for developing. The writer's own practice is to develop, fix, and wash without removing the plates from the tank, washing being accomplished by putting a hose clear to the bottom of the tank beside the rack of plates and allowing the water to flow for half an hour or an hour. Obviously, if the plates are washed free from hypo the same will be the case with the tank. Should it be desired, however, to use separate tanks for fixing and washing it will be found that hard rubber is best for the former purpose, since electrose tanks will be bulged out of shape in time by the weight of the solution in them, whereas this does not take place with hard rubber. Most of the washing boxes on the market are made of zinc and the seams open in time, and in addition to this the design is usually such that the water enters at the bottom and drains off at the top, this being the reverse of the proper method, for hypo is heavier than water and tends to sink. Should the worker wish to use a special washing box for his plates he will do well to have one made of heavy wood with two or three coats of asphaltum varnish, a hole being

placed at one end at the bottom and the water being allowed to enter at the top. Films are most conveniently washed by pinning them to sticks and allowing them to float for half an hour or so in a bath tub or bucket, since by this means the hypo readily drains out of the emulsion and sinks to the bottom of the water.

Printing frames should be substantially made and should preferably be of the two-thirds opening type, since this affords better opportunity for examining the print. It is well to have one or two frames of a size larger than the largest negative to be printed from and to have these fitted with 1/8 or 3/16 inch plate glass, since it is necessary in multiple carbon work to cut the tissue larger than the negative, and in multiple gum printing it is convenient to do likewise with the printing paper. A retouching desk will be found convenient, not only for pencil work on the negative but also for spotting out pin-holes, and the opening in the desk should preferably be large enough to afford a view of the entire negative. As to pencils, brushes and spotting mediums, little can be said except that the magazine pencils are the most convenient, that the best brushes are the small Japanese paint brushes and that moist water colors, though very desirable for spotting prints, are not as good for spotting negatives as the opaque which is furnished for this express purpose.

PART II

NEGATIVE MODIFICATIONS

CHAPTER VI

MANIPULATION OF NEGATIVES

Manipulation of the Negative.—It sometimes happens that the worker, either through failure in judgment or through exceptional conditions, does not succeed in obtaining the precise quality of negative desired, in which case much may be done to improve matters by either intensification or reduction. Also it not infrequently occurs that the relative values in the negative are not such as to give the best pictorial effect, even though they may be a correct rendering of the gradations in the original subject. In this case local intensification or reduction may advantageously be employed or the values may be improved by working with a pencil on either the front or the back of the plate, if the surface has been prepared so as to take the pencil well.

Intensification.—There are many different intensifiers available, some of them useful and others distinctly undesirable, so it may be well to indicate what the characteristics of an intensifier should be.

In the first place, it should be capable of absolute control; that is, it should give either slight or great intensification, as may be desired. Second, it should be capable of being made up in a single solution which will keep well both before and after using. Third, it should not cause stains when handled with ordinary care. Fourth, it should give a deposit approximating in color that of the negative, that is, a neutral black or

a warm black, since if it gives either a yellow or a red color it will be difficult to judge by inspection the degree of intensification. Fifth, the intensification should be permanent. There are two intensifiers which fulfil these requirements admirably; namely, the mercuric bromide and the mercuric iodide intensifiers, although these vary somewhat in their method of use and in the character of the results obtained. Mercuric bromide intensifier is made up as follows:

Water	16 ounces
Mercuric chloride	150 grains
Potassium bromide	150 grains

The negative should be washed free from hypo and the intensifier may be applied at any time thereafter, either before or after drying the plate. The negative is immersed in this solution until it is completely bleached and is then washed in running water for about half an hour. After washing it is blackened in a solution of sodium sulphite, the strength of which is not very material, although 10 per cent. is a good standard. After blackening it is washed for half an hour and is then gently swabbed with a tuft of cotton, rinsed and dried. The bleaching solution may be used repeatedly until exhausted. This intensifier tends to reduce slightly the very thin portions of the negative at the same time that it intensifies the half tones and lights, for which reason it is recommended in the case of a negative which has been slightly over-exposed and under-developed. The increase in density in the lights is about 40 per cent. and if desired the operation may be repeated with a slight further increase in contrast.

Some writers recommend giving the negative three or four minutes in each of two acid baths consisting of

Water	10 ounces
Hydrochloric acid	1 dram

these acid baths to be applied after the plate has been washed from the bleacher for 10 or 15 minutes and to be followed by 10 or 15 minutes further washing before blackening. The writer, however, has not found that this treatment with acid is of any practical advantage, though it may be so on theoretical grounds, and at any rate it can do no harm. It will be seen that the increase in contrast with this intensifier is practically a fixed quantity, for although it is possible to arrest either bleaching or blackening before it is complete, so doing is likely to result in irregular intensification.

The mercuric iodide intensifier is made up as follows:

(A)	Water, distilled, hot	14 ounces
	Mercuric chloride	300 grains
(B)	Water, distilled	7 ounces
	Potassium iodide	840 grains

Allow A to cool and pour B into A slowly while stirring. At first a thick orange-colored precipitate is formed, but with further addition of the iodide solution this precipitate is dissolved and a clear solution of slightly yellowish tinge results. This forms the stock solution and may be used either concentrated or diluted with three or four volumes of water, both the concentrated and dilute solutions keeping well after using as well as before. The diluted form is preferable, since the action is more under control and also for the reason that the con-

centrated solution often has a tendency to soften the gelatine film, causing at times serious frilling and even in extreme cases complete loosening of the gelatine from the glass. Should it be desired to use the strong solution the negative should be given 10 minutes in a 1 to 10 formaldehyde bath and be washed and dried before intensifying. This intensifier may be applied to the negative when the latter is either wet or dry and it is not strictly necessary to have the hypo completely out of the film before intensifying, although this is desirable. The plate to be intensified is immersed in the intensifying solution, the tray being rocked constantly, and the gain in density is watched until it has reached the desired point, which can be clearly determined after a little experience. The negative is then removed from the tray and washed for ten minutes in running water, where it will assume a distinctly yellow color. Some writers recommend the use of acid baths in this case as well as in the case of the mercuric bromide intensifier, but the writer has not found this treatment necessary. After washing, the plate may be dried if time is of importance, but in this case the intensification will gradually fade and for stable intensification the plate should be blackened in any standard developer, when the intensification will be practically permanent. After blackening, the negative should be washed for half an hour in running water and be swabbed with a tuft of cotton and rinsed before being put to dry. This intensification strengthens all the gradations in due progression, the maximum increase possible being about 70 per cent., and subsequent treatment or longer treatment is of no ad-

vantage, though if intensification has been arrested before the maximum increase was obtained the operation may be completed at any time afterward.

Should local intensification be desired the mercuric iodide intensifier is the more desirable, since the increase of density can be determined directly by examination. For this purpose it should be applied in dilute form with a tuft of cotton or soft camel-hair brush, the negative having previously been soaked for an hour in water. Subsequent manipulations are the same as with general intensification.

There are other intensifiers which will give greater contrast than the mercuric iodide, notably the Wellington silver intensifier, especially if this be repeated or followed by mercuric bromide, but for practical purposes the mercuric iodide will be found to give as much intensification as is likely to be desired.

Reduction.—There are three methods of reduction, which show different characteristics. Farmer's reducer tends to attack the shadows first, effecting considerable reduction in the thin portions of the negative before the lights are greatly affected. It is therefore desirable in the case of negatives which have been over-exposed and are so dense as to print slowly, without having the desired contrast. Ammonium persulphate, on the other hand, attacks the denser parts first, so that considerable reduction of contrast may result before the shadows have been perceptibly attacked, and it is therefore advised in the case of negatives which have been under-exposed and over-developed, as was indicated in Chapter IV. There is a third reducer, potassium permanganate, which attacks the deposit of silver uniformly,

decreasing density, but neither increasing nor decreasing contrast. It will be apparent that since reduction is actually a process of solution of the silver image, caution must be exercised in the operation, for a deposit that has been dissolved out can never be restored. These reducers will all be found to work slowly and clearly without risk of stain or irregular reduction provided the directions are followed.

To employ Farmer's reducer two stock solutions should be made up, the first being

Water	10 ounces
Potassium ferricyanide	1 ounce

The second is

Water	10 ounces
Hypo	1 ounce

These solutions will keep indefinitely, but it should be noted that after mixing they keep only a few minutes and that the ferricyanide solution should be kept in the dark. The negative to be reduced should be free from hypo (or irregular reduction may result) and should be soaked in water for one hour before reduction. The working solution is made up in the proportions of

Hypo solution	1 ounce
Ferricyanide solution	1 dram

and the negative is immersed in this in a tray, preferably a white porcelain or porcelain-lined one, since this facilitates watching the process of reduction, the tray being rocked continuously. The negative is examined from time to time by transmitted light, and should be rinsed before holding it up for examination or streaks will probably result. When reduction is complete the negative is washed for half an hour in running water

and set up to dry. The deterioration of this reducer becomes evident by a change in color from lemon yellow to pale green, after which it is useless and must be replaced by fresh.

To reduce with ammonium persulphate, the negative should be free from hypo and should be soaked in water for one hour before treatment. The ammonium persulphate solution should preferably be made up fresh at the time of using, although a 10 per cent. solution will keep satisfactorily if made with distilled water and closely stoppered. The working solution is made up as follows:

Water	2 ounces
Ammonium persulphate	20 grains
Sulphuric acid C. P.	1 minim

The wet negative is placed in this solution and the tray rocked until sufficient reduction has taken place, when the action of the reducer is arrested by transferring the plate to a 5 per cent. solution of sodium sulphite, the plate being subsequently washed for half an hour in running water and set up to dry. It is advised not to keep the plate in this reducer for more than five minutes or uneven reduction may result. If sufficient reduction has not taken place in this time the plate should be rinsed and transferred to a fresh bath.

There are several methods of employing the potassium permanganate reducer, probably the most reliable being as follows. The well-soaked negative is immersed for not more than 1¼ minutes in a bath of

Water, distilled	20 ounces
Potassium permanganate	5 grains

It is then rinsed in several changes of water and transferred to a 10 per cent. hypo solution for three or four

minutes, afterward being washed for half an hour in running water and set up to dry. Should the reduction be insufficient the operation may be repeated. If the plate shows a yellow stain after reduction, this may be removed by a few seconds' immersion in a bath of

Water..................................	5 ounces
Hydrochloric acid C. P....................	20 minims

this bath being applied after the plate is washed and being followed by slight rinsing before drying.

If local reduction is to be effected it is best to soak the plate for an hour in a bath of

Water....................................	10 ounces
Hypo......................................	2 ounces

and apply Farmer's reducer with a tuft of cotton. This action should be carefully watched and the plate rinsed from time to time, the object of soaking in hypo solution instead of water being to diminish the likelihood of the reduced portion showing a sharp outline, and if it is desired to follow a definite line with the reducer (which, however, is not generally recommended), the reducer should be applied to the dry negative with a fine camel-hair or sable brush.

Retouching on the Film.—It is sometimes necessary to raise the value of small areas, as in touching out freckles in a portrait, and this is best done on the film when the lightening required is not great. Ordinarily a pencil will not take freely on the film unless this has been especially treated, though in the case of an intensified negative it will sometimes do so. There are many retouching mediums on the market, but the best which the writer knows is that for which the

THE DANCE
BY EDWARD R. DICKSON
From a Platinum Print

formula is given in the manual of the G. Cramer Dry Plate Company, this being as follows:

Turpentine	4 ounces
Rosin	120 grains

It is not necessary to use especially pure rosin and turpentine, the commercial article being quite satisfactory. The rosin is dissolved in the turpentine and the medium is applied to the film with a piece of lintless cloth, a very slight amount being necessary. The cloth should be merely dampened and the film rubbed with it, but it is desirable to continue the rubbing until the medium is dry (which is a matter of a few seconds only), as if this is not done the negative will probably show a definite outline where the medium has been applied, this being especially true of an intensified plate. One application of this medium will give sufficient tooth to permit of considerable work with an H B or a B pencil, although if more tooth is required it is necessary to use a greater amount of rosin in the medium. If the work proves unsatisfactory it is easy to clean the pencil marks off by means of a cloth dampened in the medium, when the work may be done over again. It is desirable to have a long point to the pencil and this point in general should be kept very fine, a piece of number 0 sand-paper being useful for sharpening the pencil. It is not necessary to practice any of the special marks used by professional retouchers, such as commas, cross-hatching, etc., for a little care in working will enable the photographer to apply the graphite only where it is wanted, the important point being to work slowly and not attempt to put on too much at once. The negative, of course, should be

supported in the retouching desk while work is being done on it, and should be examined by transmitted light, proofs being taken from time to time in order to see how the work is progressing.

RETOUCHING ON THE BACK.—When large areas are to be raised in value or when the lightening is to be great, it is best to apply ground glass varnish or tracing paper to the back of the negative and work on this with pencil or stump. An excellent formula for ground glass varnish is the following:

Gum sandarac	90 grains
Gum mastic	20 grains
Ether	2 ounces
Dissolve and add	
Benzole	¼ to 1½ ounces

The quantity of benzole added determines the nature of the matt obtained. To apply this the negative is supported in the left hand and a small pool of the varnish is poured on the back, which, of course, should be thoroughly cleaned and should be free from dust. The negative is then tilted so that the varnish runs all over the plate, the excess being drained back into the bottle from one corner. After some practice it will be possible to flow the negative neatly without getting any of the varnish on the film side, but any which does get on the film may readily be cleaned off by means of a rag wet with alcohol after the varnish has dried, which it will do in a few seconds, and should the pencil work not be as desired alcohol will remove the ground glass varnish, and the negative may be flowed again.

If it is preferred to use tracing paper, this should be selected with as fine a grain as possible and of as pure a white as can be obtained. A line about 1/8-inch

wide of LePage's or Dennison's glue or of Seccotine is run around the edges of the negative on the glass side. The tracing paper, which should be cut slightly larger than the negative, is dampened by means of a sponge and is laid on the negative, being pressed down so as to insure firm adhesion of the glue. The negative is then set aside until the paper is dry, when the latter will be found to be stretched taut and smooth. Care should be taken that the paper is not dampened too much, as if this is done it will expand so much that on drying it will probably split. Work may be done to almost an unlimited extent on this paper with a pencil, but should it be found that the paper will not take enough graphite water colors may be used. Evidently, if the work proves unsatisfactory the paper may easily be removed from the negative and be replaced by fresh. It should be noted that work on the film is in contact with the printing paper, so must be done with greater precision than when it is on the back, as in the latter case the pencil lines give a diffused image, owing to their separation from the sensitive surface.

If it is desired to darken an area, this may be done either by working on the film with a fine-pointed pencil eraser, which should be rather hard instead of the sort known as putty rubber; or the etching knife may be used, although the latter is not recommended unless it is desired to remove entirely a portion of the film, since it is difficult to do only a slight amount of work in this manner. A method which is far preferable to using the etching knife is to incorporate a slight amount of yellow dye with the ground glass varnish (aurantia is recommended) and to scrape away the varnish from

the areas to be darkened. Obviously this method allows of doing the work over in the event of its proving unsatisfactory at first, which is not the case if the etching knife is used. A very small amount of dye will give a marked effect.

Combination Printing.—It sometimes happens that it is desired to combine portions of two or more negatives, as in printing clouds or figures into a landscape, and there are several ways of accomplishing this.

The first and simplest is to cut a mask the size and shape of the portion to be printed, keeping both pieces of the black paper; namely, the portion which is cut out and the large sheet from which it is cut. The first negative to be printed from is placed in the printing frame with the paper on which the print is to be made and the portion of it which is not desired is shielded by means of one portion of the mask. When printing has gone far enough the paper and negative are removed from the frame and the other negative is placed in it, the printing paper being adjusted in register with the second negative. The other portion of the mask is then used to shield the paper from light and the second negative is printed to the proper depth. Obviously this method is applicable only to printing-out papers unless special means are employed for insuring registration, and in any case it is not easy to manipulate the masks with such accuracy as to show no outline at the junction.

Another method for securing the same result is to make a print of the entire first negative, then to make a print of the second and to cut out with a sharp knife from this print those portions which are not desired in

the completed picture. The second print is then fastened in the proper position on the first by means of a few touches of glue and the whole is copied. The negative so made will probably show the outline of the second print on the first and this should be retouched carefully. If the scale of the two negatives is different one or the other must of course be enlarged and a portion of the enlargement (which may be on bromide paper) must be used. This method will be found simple and satisfactory.

A third method, no more satisfactory than this and far more complicated, is that given by the late A. Horsley Hinton in Photo Miniature No. 59, but a full description would require more space than can be given here.

There are numerous opportunities for failure in combination printing, but careful work and precise observation will enable the photographer to avoid them. Care must of course be taken that the scale is the same throughout; that is, if figures are printed in a landscape they must not be too large or too small and they must have the proper value or there will be a discrepancy between linear and atmospheric perspective. It may seem unnecessary to state that objects printed in a landscape, whether clouds, figures or trees, should be lighted from the same direction as the landscape, but the writer has seen prints in which this precaution has not been taken, the effect being bizarre in the extreme. Necessarily, also, the quality of definition should be the same throughout. It may seem absurd to call attention to these evident facts, but it is necessary that the worker's observation be as precise and accurate as that of any other individual who will be likely to see

the picture, since incongruities of any sort will spoil the psychic effect of the work. Ordinary care would of course prevent such violations of unity as can be seen in a picture by a well-known worker, where clouds have been printed in a marine, the work having been done with such indifference that the cloud forms have been printed directly over the sails of a yacht in the foreground.

Combination printing is not easy to do, but the results often justify the labor expended, and in fact the thorough artist will not consider any amount of labor excessive, provided it affords exactly the effect which he wishes to obtain, it being far better to spend six months in the production of one satisfactory picture than to make a hundred mediocre ones in the same time. Michael Angelo is credited with having said to a person who remonstrated with him for giving so much attention to trifles: "Trifles make up perfection and perfection is no trifle." Whether or not the great Italian ever actually said this, it is nevertheless perfectly true, and although the writer prefers whenever possible to obtain the completed picture from one original negative, it cannot be too strongly impressed on the student that retouching, combination printing, and modification of the print are all necessary at times, and the worker should not permit himself to be influenced by those writers or advisers who maintain that such methods are not legitimate photography. The final result is the only thing to be considered and the worker's attention should be concentrated on securing the pictorial effect, without, however, introducing any violations of unity resulting from an evident mixture of mediums; that is, photography and hand work.

CHAPTER VII

ENLARGING

Reasons for Enlarging.—Many writers say that size has nothing to do with art and that it is possible for a small picture to show as fine artistic quality—that is, composition of line and mass and esthetic feeling—as can be found in a large one. This is perfectly true, but the fact remains that pictorial effect depends to a great extent on the size of the picture, and that the larger the print the more likely it is to produce the desired effect on the spectator. This is probably due to the circumstance that the photographer or painter who wishes to produce a psychic impression, that is, to arouse in the spectator some mood or emotion—which is the highest function of art—is necessarily concerned very largely with producing an illusion of reality, the psychic effect being more likely to result if the observer can be deceived into thinking he is looking at the actual objects instead of merely their pictorial representation. Since natural objects are usually large as compared to the observer, it follows that a picture of a tree or a house is not likely to produce an illusion of reality when it is on a small scale, for the observer is obliged, in looking at the real tree or house, to move his eyes in order to observe the entire object, whereas this does not occur with a small picture. If, however, the picture be 18″×22″ or 20″×24″ it will be necessary for the observer to move his eyes in order to see the entire picture space, and this motion is unconsciously asso-

ciated with the idea of magnitude. Hence it follows that those artists who are concerned merely with esthetic qualities need not work in large sizes, but the ones whose ambition it is to produce a pictorial effect should make their prints as large as possible without exceeding the natural limitations of the medium. Ordinarily it will be found that the practical limit of size is about $20'' \times 24''$, but it is also true that a print $11'' \times 14''$ has much greater carrying power than one $8'' \times 10''$, the smaller being essentially portfolio prints rather than wall pictures.

Reasons for Making Enlarged Negatives.—There are several reasons why it is preferable to make an enlarged negative and a print from it, rather than to enlarge direct on bromide paper, the most important being that bromide paper cannot be considered absolutely permanent, but scarcely second to this in consequence is the fact that it is not possible to get so fine a quality in the lower register with bromide paper as with various of the other mediums. Also, the possibilities of bromide paper are limited unless the worker resorts to various toning methods, most of which still further diminish the stability of the result. Further, modification of relative values may be carried out more readily on a large negative than on a small one, and all of these factors operate to make it practically imperative for the pictorial worker who wishes to produce large prints to make enlarged negatives and contact prints in one or another of the better mediums.

Enlarging Methods and Apparatus.—There are almost as many styles of enlarging apparatus as there are styles of camera, the simplest being the fixed focus

enlarger, which consists merely of a light-tight box having at one end a space for holding the sensitive paper or plate and at the other a space for holding the negative or positive to be enlarged from, with a lens arranged at the proper point inside the box so that an enlarged image of the negative or positive is projected on the sensitive surface. This instrument is limited in its application, since the enlargement always bears a definite relation to the original, the degree of enlargement being usually two diameters; that is, $4'' \times 5''$ is enlarged to $8'' \times 10''$ or $3\frac{1}{4}'' \times 4\frac{1}{4}''$ is enlarged to $6\frac{1}{2}'' \times 8\frac{1}{2}''$. These instruments are very cheap and within limitations do excellent work, but far preferable to them is a more flexible piece of apparatus. This may be either a projection lantern, arranged somewhat like the familiar stereopticon, or it may be a copying camera, which differs from the fixed focus instrument in having an extensible bellows so that any degree of enlargement within the limits of the instrument may be obtained, and is usually constructed with the same mechanical care as a good camera. The copying camera has the disadvantages that it is rather expensive and that it is extremely bulky if enlargements greater than $11'' \times 14''$ are desired, whereas the projection type is relatively cheap and compact and gives enlargements of practically any desired size, but has the disadvantage that it must be used in the dark room, since the sensitive substance on which the large negative is to be made must be fastened to an easel instead of being contained in a plate holder as is the case with the copying camera. Generally speaking the writer would prefer a copying camera if enlargements not over

$11'' \times 14''$ are to be made, and for sizes greater than this the projection apparatus.

Daylight and Artificial Light.—Either daylight or artificial light may be used for illuminating the original, daylight having the advantage that it requires as a rule far less exposure than any artificial light, whereas artificial light has the advantages that it is more uniform, so that errors in exposure are less likely to occur, and that its use makes possible working at night. If daylight is employed it is generally necessary to use some method of diffusing it so that shadows falling on the window will not be reproduced in the enlargement, and this may be accomplished by closing the window completely with an opaque shutter except for an area of the desired size and in this opening placing two or three sheets of ground glass separated from each other by about two inches. If artificial light is used it will be necessary either to diffuse the light in this manner or to employ between the source of illumination and the negative or transparency a pair of condensing lenses, the function of these being to refract all the rays falling on them from the illuminant into a cone of light the apex of which is approximately at the diaphragm of the projection lens. It will be apparent that the use of condensers diminishes the necessary exposure and the projection type of apparatus is generally supplied with this adjunct. Figure 40 shows arrangements of three forms of enlarger, (A) representing diagrammatically the copying camera when used with daylight, (B) the projection apparatus with the same form of illumination, and (C) the projection apparatus with artificial light. Various forms of artificial light

may be used satisfactorily, among them being the incandescent gas burner, the incandescent electric light, acetylene gas, and the Cooper-Hewitt mercury vapor arc. The electric arc is not generally recommended, since it is somewhat inconvenient to operate. It should be observed that if condensing lenses are used the

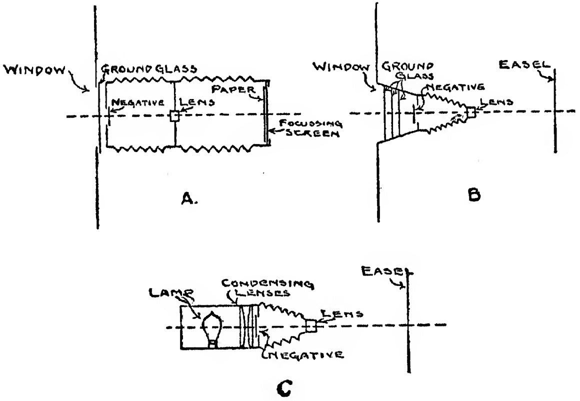


FIG. 40.

source of illumination and the axis of the projection lens should be accurately in line with the axis of the condenser or uneven illumination at the easel may result, which will also be the case should the projection lens and the source of illumination not be approximately at the conjugate foci of the condensing system. Therefore some means should be provided whereby the illuminant may be moved nearer to or farther from the condensers, so that a uniform screen may be obtained

whether the projection lens is racked forward or back as may be necessary for different degrees of enlargement.

It is possible to obtain an arrangement known as an "enlarging back," this being a device which carries the small negative or transparency and several sheets of ground glass for diffusing, the whole being capable of attachment to a shutter, and fitting the back of a view camera. This device is strongly recommended to anyone who possesses a view camera and wishes to work by daylight or mercury vapor arc, since it furnishes a relatively cheap and thoroughly satisfactory means for enlarging.

Glass or Paper Negatives.—Either dry plates or bromide paper may be used for the enlarged negatives, the writer generally preferring the latter for the following reasons:

1. It is cheaper.
2. It is lighter and more compact for storage.
3. It is easier to manipulate in the dark room.
4. Modification of relative values may be made directly on the paper with pencil or stump without the need of retouching medium or ground glass substitute.
5. It is impossible to over-develop a negative on bromide paper, since development proceeds as far as the exposure demands and then ceases, there being observable a definite point at which development stops, so that one possible source of failure is thus avoided.

The advantages of dry plates are:

1. Printing is slightly more rapid for a given quality of negative. This, however, is not of great importance, as may be understood from the fact that

many of the writer's paper negatives print on platinum in three or four minutes with bright sunlight, and it often happens that a glass negative will require more time. Generally speaking the increased printing time of paper negatives over that of glass is of no importance, especially to the pictorial worker, who does not, as a rule, wish to make more than a few prints in a day.

2. Dry plates are capable of giving finer detail than bromide paper, since the grain of the paper stock tends to break up fine lines. This, however, may be a disadvantage, as the pictorialist generally desires breadth rather than minute definition.

3. It is a little easier to manipulate glass negatives in printing, but the difference is so slight as to be hardly worth noticing.

4. Should the quality of the transparency not be as desired it is easier to correct the fault by shortening or prolonging the development of the large negative than is the case with bromide paper.

Some workers use Eastman Portrait Film for enlarged negatives, and this is very good, the chief disadvantage being the extreme rapidity of the emulsion, which makes it difficult to secure correct exposure, and the fact that the larger sizes, if printed in sunlight, tend to buckle in the printing-frame, giving streaked prints.

Technique of Enlarging.—Obviously if an enlarged negative is to be made it must be made from a transparency instead of from a small negative, and the quality of the transparency is of prime importance. The contrast in the transparency must be adjusted to the medium to be used for the large negative, and although no definite rules can be given for securing the desired contrast, since this varies according to cir-

cumstances, nevertheless some general indications may be given. A fast-working plate will require a stronger transparency than a slow one, the same being true of bromide papers, since slow emulsions tend naturally to give more contrast than rapid ones. Also, the stronger the light used for projection the stronger the transparency must be, since a powerful illuminant tends to give softer results than a weaker one. The writer's own practice is somewhat as follows. The light used for projection is a powerful 500 watt tungsten incandescent with condensers and a fast-working bromide paper is generally employed for the negative. The transparency is made on a Standard Orthonon or Seed's L. Ortho Non-Halation plate, this being placed in contact in a printing frame with the original, which is usually rather soft. An exposure of about one second is given at a distance of four feet from an incandescent gas burner and the transparency is developed in a soft working developer until it has a slight tone in the lights and an ordinary newspaper may be read through the densest portion when the transparency is laid directly in contact with the paper, this determination of course being made after the transparency has been fixed, washed and dried. It will be seen from this that the transparency is distinctly thin in the shadows and has a slight veil in the lights, no part being clear glass. The resultant negative is decidedly soft in quality, and will give in platinum a print having tone in the lights and medium or dark gray shadows. Of course, this technique is varied when a different result is desired, but it will always be found that a double-coated plate is desirable for the transparency, since a single-coated

plate is very apt to show halation when used in these circumstances. For making the large negative the writer generally prefers a fast bromide paper, choosing of course one in which the emulsion is coated on a thin stock, in order that printing may be as rapid as possible. If, however, a plate is to be employed, the one chosen is of the comparatively slow non-halation variety, since this approximates very closely to the working quality of the paper mentioned. The paper is in itself halation proof, as has been stated in Chapter III. With the illuminant and transparency indicated the exposure for enlarged negatives will generally be about 15 or 20 seconds, and the paper or plate is developed in a fairly strong solution, generally the metol-hydroquinone developer given in Chapter IV, taking one ounce of stock solution to 15 ounces of water. Development will be complete in two or three minutes and the negative is then fixed in an acid hypo bath and washed for half an hour in running water. If several large paper negatives are made and washed together care should be taken that the flow of water into the tray is such as to keep the negatives separated or they will not wash thoroughly and stains may appear at a later date. It will be found that some bromide papers show a decided tendency to curl when dried, and if this is inconvenient it may be prevented by soaking the negative immediately after washing in

Water	15 ounces
Glycerine	1 ounce

and hanging up to dry. As indicated above, paper negatives may be modified directly with pencil or

stump as desired, and either paper or glass negative may be intensified or reduced either locally or generally by the methods given in Chapter VI.

Sometimes the transparency is made by the carbon process, using either the special transparency tissue or the Ivory Black, and printing from two to ten times as long as would be done for a print on paper. The tissue is transferred to ground glass, no special preparation of the latter being necessary, since the roughness of the glass will cause the tissue to adhere perfectly. The ground glass will cause some diffusion in the enlargement, and if this is not desired the transparency may be flowed with Lumière's autochrome varnish, which will do away with the granular effect.

Some workers advocate making a large transparency by projection and making the negative from this by contact printing, but the writer does not feel that any better quality results from this method, which has the disadvantage of being decidedly more expensive. If it is desired to adopt this method, it is advised that the large negative be made by the carbon process, using Ivory Black tissue, printing about ten times as long as for a paper print, and transferring to ground glass, since this reproduces the gradations of the positive automatically, and there is less opportunity for failure through incorrect development.

Bromide Enlarging.—If the worker does not wish to make enlarged negatives and is willing to accept the limitations of bromide paper he may make enlargements direct in that medium, the process being the same as in making enlarged negatives, except that the enlargement is made from the original negative instead of from a

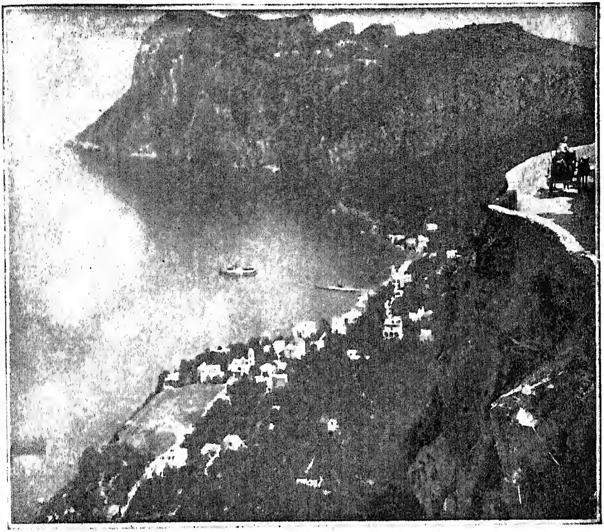
transparency. The limitations in question are: (1) impermanence unless redeveloped to a brown color; (2) the impossibility of securing as rich blacks as are obtainable with other mediums; (3) the surface texture of bromide paper is not so pleasing as that of some other papers.

Bromide paper may be obtained in many different grades and surfaces, from glossy to dull, in many different degrees of contrast, and in many textures, from smooth to very rough. It is possible to obtain bromide papers the surface of which approximates closely to that of platinum paper, and there is one in which the emulsion is coated on a Japanese tissue, this paper being capable of giving very beautiful results. Bromide paper is also furnished in a variety of weights, and in white or buff stock, the latter being especially suitable for sunlight effects and for portraiture, particularly when redeveloped to give a brown image.

In bromide enlarging one of the most important points is to have the strength of the negative adjusted to the paper in use, since it is not easy to introduce variations in contrast by varying the treatment of the paper. If the negative is too strong a soft print may be obtained by over-exposing and developing in a very dilute solution, arresting development before complete, that is, when the appearance of the print is satisfactory; but this is not easy to do, and if the print is to be redeveloped such treatment will certainly result in a poor color. If the negative is too weak it should be intensified, for, although a bromide print may be intensified in the same manner as a negative, this tends to diminish the stability of the image. If rich prints are to be

obtained the negative should be of such quality that normal treatment will just give the desired quality in the lights and at the same time will give the darkest shadows which the paper is capable of rendering. In other words, it should exhaust the scale of the paper, for bromide paper is not a long scale process, and does not, normally, give as strong shadows as platinum or carbon. If the print is to be redeveloped, however, the negative should not be too strong, for the shadows must not be blocked up, any suggestion of reversal—from over-exposure—giving a poor color.

Practically any developer may be used, though it is advised to employ that recommended by the manufacturer of the paper in use, and it may be noted that a strong amidol developer tends to give a cold black. Pyro is not generally recommended, on account of its staining tendency, though if carefully used it may be made to give a very pleasing warm color. Generally speaking, the developer should be used rather strong, especially if the print is to be redeveloped. An acid fixing bath with hardener is advised, particularly if the print is to be redeveloped, since this operation tends to cause blisters. Washing should be thorough, for on the removal of the products of fixation depends the stability of the print, and it is imperative that all the hypo be removed from the emulsion of a print intended for redevelopment, since any hypo remaining in the film will combine with the potassium ferricyanide in the bleacher, forming Farmer's reducer, which will dissolve out portions of the silver image, spoiling the print. The fixing bath should be renewed at frequent intervals, for it will apparently work satisfactorily after



CAPRI
BY KARL STRUSS
From a Bromide Enlargement

bleacher very dilute and arresting bleaching when only partially completed, by rinsing the print quickly in water, the subsequent operations being the same as in the other case. If this is done the final image will consist partly of black metallic silver and partly of brown silver sulphide, the exact color depending on the extent of the bleaching. Some workers find it difficult to secure uniform bleaching when using this method, but if the print is dried before bleaching there should be no trouble. An alternative method is to bleach fully, to redevelop partly in a very dilute non-staining developer, and to complete redevelopment in the barium sulphide solution, the final image in this case also consisting partly of metallic silver and partly of silver sulphide.

Whether the prints are black or brown the richness of the shadows and the brilliance of the lights are greatly increased by varnishing. If it is desired to varnish without changing the color of the print French picture varnish diluted with alcohol may be used, the print being dipped into this and hung up to dry. If a slight yellowing of the print is not objectionable Johnson's or Old English floor wax may be used, being applied with a brush or rag and polished with a moderately stiff brush, the final polish being given with a soft cloth. This improves the appearance of a strong print to a marked degree.

PART III

PRINTING METHODS

CHAPTER VIII

THE IDEAL MEDIUM

No printing medium possesses all the characteristics which are desirable, and the selection of the medium in which the negative is to be rendered must therefore depend on the particular qualities that are to be secured in the completed picture. Thus, some mediums will render the lighter gradations satisfactorily but fail to give good quality in the lower register, whereas others are satisfactory in shadow rendering but fail to give good quality in the lights. Also, some mediums which render gradations nicely do not possess a pleasing surface texture, while others which have a good texture fail in the rendering of the tones of the negative. The present chapter will give so far as possible a discussion of the characteristics which the ideal medium should possess, and in the next chapter the different mediums will be considered with reference to the advantages and disadvantages of each.

Permanence.—If pictures are made for sale necessarily honesty demands that they should not be likely to deteriorate in the course of time as the result of exposure to light and air. All of the mediums considered in this book possess this characteristic except that the pigment mediums may be fugitive if improper pigments are used and that a black and white bromide print cannot be considered absolutely stable. If, however, the proper colors are selected these mediums may be as stable as an oil painting or a charcoal sketch, and it is known

that charcoal drawings are in existence to-day which were made at least 20,000 years ago. Of course, no picture is necessarily permanent, since any may be destroyed, but some mediums are so unstable that the image will partially disappear in the course of comparatively few years, even if carefully treated.

Rendering of Gradations.—The printing medium should be capable of rendering with absolute fidelity all of the gradations of the negative from pure white to pure black. Since these gradations may proceed by imperceptible transitions it necessarily follows that the paper must be highly sensitive to slight variations of light action, although it is of course possible to make a negative in which the scale of gradation exceeds the power of any printing paper to render, this being due to the fact that the negative is examined by transmitted light, whereas the print is examined by reflected light, and the paper support on which the image rests absorbs a considerable proportion of the incident light.

Texture.—Although the superficial texture of the print has nothing to do with the pictorial effect, which depends solely, so far as the print is concerned, on the rendering of the gradations of the negative, nevertheless this matter of texture is of considerable importance, the esthetic value of the picture depending on it to a great extent. That is, if the surface of the print is of a quality which is inherently unpleasant to the eye, the observer will unconsciously be repelled by it, this feeling of displeasure being at times so great as to impair seriously the psychic effect of the picture. It is generally accepted that a dull surface is more pleasant to the eye than a glossy one, though for some effects a

lustre may be preferred, and it is also usually the case that a slight roughness is more agreeable than a smooth surface, especially if the roughness is irregular in character.

Modifications of Color.—Photography is essentially a monochromatic art, although at times variations of color are introduced. Still, the color chosen for a picture may be of great importance as regards the pictorial effect, as will be realized if we consider the result of printing a snow scene in brown. The prevailing tone of a summer or autumn landscape is generally warm; that is, tending toward yellow or red rather than toward blue, and that of a spring or winter landscape is generally cold. If an unsuitable color is used for printing, it will be difficult to produce the desired illusion of reality, and the printing medium should therefore be flexible in this respect, though it is generally desirable to avoid the more pronounced colors, such as blue, green, and red, and to confine oneself to cold, neutral, and warm black and to various shades of brown. If the worker's aim is merely to produce an esthetically pleasing result and no value is attached to the illusion of reality, a neutral black will generally be found most satisfactory.

Modifications of Relative Values.—It should be possible within limits to modify relative values in the print, since it is often inconvenient to make in the negative the changes necessary to pictorial effect. This, however, is not of great importance, for such changes can always be produced in the negative if the worker will give the necessary time and effort, and the power of modifying values in the print may sometimes constitute

a positive disadvantage, the worker being apt to be led astray by this ability and to do more than should properly be done.

MODIFICATIONS OF TOTAL CONTRAST.—It is important that the printing medium should be readily controlled as regards total contrast; that is, difference between the extremes of light and dark, since it is often inconvenient and sometimes impossible to intensify or reduce the negative in the desired manner. Of course if one were always sure of producing the proper quality of negative and were always sure of making the final print in the medium chosen, this flexibility in the printing medium would be of no importance, but it is obviously impossible to be certain of always obtaining the proper degree of contrast in the negative and it not infrequently happens that the photographer will ultimately decide on a different printing medium than the one originally selected, so that the ability to control the contrast in the print is of no slight consequence. It is true that greater contrast may be secured by printing slowly, whatever the medium may be; that is, a print made in the shade will always show more contrast than one made on the same paper from the same negative if printed in direct sunlight, but practically this method of variation is limited in its application. The writer has known of a satisfactory print being got from an exceedingly soft negative by printing far away from a window, the actual printing time being forty-eight hours, whereas printed in direct sunlight the negative in question would have required not over twenty seconds, but it is seldom convenient to make use of any such prolonged exposure as this and the ideal

medium would permit of the desired result being obtained more readily.

CONVENIENCE.—Convenience and rapidity of manipulation are not so important to the pictorial worker as to the commercial photographer, since the former does not usually wish to turn out prints in quantity, being more concerned with the production of a few pictures of high quality. Other things being equal, however, the more convenient method is to be preferred and it is regrettable that the finest printing mediums (with the exception of bromoil) require either daylight or else a very powerful artificial light such as the mercury vapor arc, many amateurs who do exceedingly fine work being so situated that their daylight hours for working are limited to Sundays and holidays.

DUPLICATION.—One of the advantages of photography over most mediums of expression is the faculty of duplication, whereby any number of identical or closely similar prints may be made from a satisfactory negative, and, though this power is of more value to the commercial than to the pictorial worker, nevertheless it is by no means to be ignored by the latter, and it is to be regretted that with the finer pictorial mediums duplication is not easy unless the prints are made at the same time. If extensive local work has been done in gum or oil, it may be impossible to repeat a success.

CHAPTER IX

DISCUSSION OF VARIOUS MEDIUMS

The following chapter will give a discussion of the advantages and disadvantages inherent in the more desirable pictorial mediums, namely, platinum (commercial and hand-sensitized), carbon (single and multiple), gum, gum-platinum, oil and bromoil (including transfer), and photogravure.

Platinum, Commercial.—*Advantages*.—1. The manipulation of platinum is simpler and more rapid than that of any of the other pictorial mediums.

2. Platinum renders gradations in the lights better than does any other medium and in the half-tones and shadows as well as most of the others.

3. Modifications of color ranging through cold and neutral black, warm black, brown and sepia are readily obtained.

4. Modifications of contrast are very easily made, platinum being more flexible in this respect than most other mediums.

5. The superficial texture is generally pleasing, since the image consists of a deposit of fine particles of metallic platinum on the paper stock, no gelatine emulsion being used, for which reason the surface is lustreless.

6. Duplication of results is comparatively easy.

Disadvantages.—1. Commercial platinum is obtainable in only a few different textures, these being usually limited to smooth and slightly rough.

2. Modifications of relative values are not easily

made, it being in fact almost impossible to attain this result except by the laborious and rather unsatisfactory process of brush development with glycerine.

3. Commercial platinum paper will not render shadow gradations as well as some other mediums, nor does it give so rich a black as can be obtained with other processes.

Platinum, Hand-Sensitized.—Hand-sensitized platinum presents practically all the advantages of commercial platinum with the addition of improved rendering of shadows (through multiple printing) and the possibility of using a paper support of any desired texture or color. The only disadvantages which it possesses as compared with commercial platinum are that it is somewhat more laborious to prepare the paper than to buy it ready prepared (the sensitizing is, however, by no means difficult and requires practically no experience), that it is somewhat more expensive to prepare one's own paper than to buy the commercial variety, and that duplication is not so easy.

Carbon.—*Advantages.*—1. Carbon renders shadow gradations as well as any other printing medium and better than most.

2. Any one of about forty different colors may be used.

3. It is fairly easy to make modifications of relative values in the print.

4. It is easy to make modifications of total contrast by multiple printing.

5. By multiple printing in different colors some very beautiful effects are obtained which are quite beyond the power of most other mediums to secure; thus for portrait work if a rather strong print in red

chalk be put on a yellow paper and over this a comparatively light print in ivory black the result will be that the extreme lights will have a yellow tone, ranging through orange, red, and warm black to neutral black, this being a very desirable quality of print for portraiture.

6. Any color and practically any texture of paper support may be used.

7. A good carbon print, especially a multiple print, has a richness in the shadows which approximates that of an oil painting, this being due to the fact that the emulsion has appreciable thickness, so that the observer has the sense of looking through a layer of pigment instead of merely at it, as is the case with most printing mediums.

8. Duplication of results is comparatively easy.

Disadvantages.—1. It is not very easy to modify total contrast in single printing.

2. The process is somewhat laborious to handle.

3. It is almost impossible, except in the case of prints in a very high key, to secure a lustreless surface.

4. The process is difficult to handle in hot weather.

5. Pure high-lights are not easily obtained except by means of hand-work on the print.

GUM.—*Advantages.*—1. The choice of color and texture of paper support is practically unlimited.

2. Practically any desired color or combination of colors may be secured.

3. Modifications of relative values are made more easily than in any other medium except oil and bromoil and quite as readily as in these.

4. Modifications of total contrast are comparatively easy to make in single printing and the possibilities in this direction are unlimited if multiple prints are made.

5. In single gum printing a practically lustreless surface may be obtained.

Disadvantages.—1. By reason of its great flexibility gum is probably the most difficult printing medium to master completely.

2. Single gum is a very short scale medium and does not render shadow gradations or light gradations satisfactorily, its value being confined to the middle register. These objections, however, are overcome in multiple printing.

3. There is a looseness of texture in a gum print which militates against the rendering of fine detail, this being due partly to the character of the coating and partly to the fact that it is impossible to secure a gum print on a perfectly smooth surface, a slight superficial roughness being necessary. This, however, cannot be regarded as a disadvantage to the pictorialist, who rarely if ever wishes fine definition.

4. Duplication of results is very difficult, especially if some weeks have elapsed between making the first and the second prints.

Gum-Platinum.—If a gum print is made over a platinum by coating the finished platinum print with a gum-pigment mixture and printing a second time practically all the disadvantages of both mediums are overcome, since the platinum print renders the gradations in the lights, which are beyond the capacity of the gum, and the gum print adds the richness and gradations in the shadows which are lacking in the platinum, it being in addition comparatively easy to modify relative values and being much easier to master the technique of the process than is the case with gum

alone. For general photographic purposes the writer is inclined to consider gum-platinum as the best printing medium, though special cases may of course demand other methods, and, as will be seen later, oil and bromoil reach a higher level as mediums of artistic expression.

OIL.—*Advantages.*—1. Any color or combination of colors may be used.

2. Modifications of relative values may be made with the utmost facility.

3. Modifications of total contrast are made very easily.

4. In some respects the superficial texture is very desirable.

5. A very beautiful quality of richness and depth in the shadows may be obtained.

Disadvantages.—1. Delicate gradations are not so well rendered as with some other mediums.

2. It is practically an impossibility to obtain a lustreless surface, since the image consists of an oily pigment superposed on a film of gelatine. The lustre may, however, be greatly diminished by degreasing.

3. It is somewhat laborious to handle, since an 8″ × 10″ print will require fifteen minutes to an hour for the inking alone, to say nothing of the time required for sensitizing, printing, washing, and soaking.

4. Duplication of results is very difficult.

BROMOIL.—The advantages and disadvantages of bromoil are the same as those of oil with the following additions:

Advantages.—6. It is possible to make prints of any size from small originals without the necessity for making an enlarged negative.

Disadvantages.—5. The chemical processes involved in bromoil are somewhat more complicated than with oil and there is consequently more chance for failure.

Oil and Bromoil Transfer.—The advantages and disadvantages of oil and bromoil transfer are those of oil and bromoil, except that transferring presents the advantage of giving a lustreless surface of almost any desired texture, and that it adds a further complication with consequent additional opportunity for failure.

Photogravure.—*Advantages.*—1. Practically any color or combination of colors may be used.

2. Modifications of total contrast are easily made.

3. There is a very wide range of color and texture of stock available, although it is not possible to make a photogravure on a very rough paper, the pressure necessary being such as to flatten out any roughness which the stock may possess.

4. Absolutely lustreless prints may be obtained.

5. Great richness and depth are easily secured.

6. Duplication of results is very easy.

Disadvantages.—1. It is rather expensive.

2. It is laborious and requires a considerable degree of manipulative skill.

3. It does not render the gradations in the lights as beautifully as is the case with platinum.

4. Relative values are not easily modified.

The writer is inclined to favor photogravure when a lustreless surface is required in combination with richness of the shadows, and the rendering of delicate gradations in the extreme lights is not important. If a slight tone in the lights is acceptable the gradations may be well rendered.

CHAPTER X

TECHNIQUE OF PLATINUM

It will be found that in this chapter and in the one dealing with the technique of carbon printing, the method of procedure recommended varies somewhat from that advised by the manufacturers of the papers in question, this being due to the fact that the pictorial worker is generally concerned with producing a different class of results from those desired by the commercial photographer, the manufacturer's instructions being intended for the latter. In general, so far as pictorial work is concerned, whether plates or printing papers are in question, the manufacturer's instructions can be regarded as a starting point for the pictorialist, who will amplify and modify them in order to obtain the effects which he desires.

The Negative.—Platinum paper is exceedingly hygroscopic and spoils very quickly if exposed to moisture, wherefore it is always sent out by the manufacturer in sealed tin tubes which contain, in addition to the paper, a preservative. This latter consists of a piece of asbestos which has been soaked in a solution of calcium chloride, a very hygroscopic salt, the function of the preservative being to absorb any moisture which may be in the can. The preservative should always be kept in the can—which should be sealed with a piece of adhesive tape except when withdrawing the paper—and should it become soft it may be unwrapped and heated in the oven or over the gas until

restored to hardness. It is not well to print platinum paper in wet weather, though if it is not too long exposed to damp and is developed immediately after printing no harm will result. The effect of damp is to produce muddy tones and a general degradation of the lights.

It is generally stated by writers on the subject that platinum demands a rather strong negative, but this means simply that platinum has a long scale of tones as compared to bromide or gaslight paper, and consequently if use is to be made of the full possibilities of platinum printing the negative should have a fair degree of contrast. It is by no means necessary to use such a negative, many of the finest effects in platinum being secured with a plate which is decidedly soft and is printed in either a high, medium or low key, since platinum renders the gradations of the negative perfectly except in the case of very heavy shadows.

Printing.—Printing must be done by sunlight or by a very powerful artificial light, and should in general be continued until the details in the lights are faintly visible in a yellowish brown on the yellow ground of the sensitized surface, but this statement can be considered only a general guide, since the depth of printing will vary with different circumstances, some papers being more sensitive than others, and a soft negative when printed for high-keyed results giving a much less distinct image than if printed deeper. Some of the writer's negatives of this class give prints in which before development nothing is visible except a faint suggestion of the deepest shadows, and in such a case the only thing to do is to make a test print and note

the time required. After development of the test slip it can be determined whether or not the printing time was correct, and necessary changes in the time may be made accordingly. In any case it will be found desirable to print by time until some experience in judging the appearance of the print is gained. No definite statement can be given as to printing time, since this will vary with the quality of the negative, the kind of paper used, the quality of the light, the time of year and of day and the effect desired, but it may be said that an average negative, that is, one which exhausts the scale of the paper without having any distinct veiling in the shadows of the plate, will give normal results with three or four minutes' exposure to bright sunlight in summer. Some of the writer's negatives require not more than twenty seconds for a high-keyed print, whereas others may need fifteen or twenty minutes when a low-keyed result is desired.

Development.—Printing being complete, the next step is development, and this may be carried out in an ordinary room, merely taking care that direct sunlight does not fall on the print during either development or the earlier stages of clearing. The developer is fundamentally a saturated solution of potassium oxalate in water, though other substances are sometimes added to secure special effects. Such a solution may be made up by dissolving a pound of oxalate in forty-eight ounces of hot water and allowing it to cool, this forming a stock solution. It may be found with some samples of water that a slight cloudiness results, which, however, will settle to the bottom of the bottle, allowing the clear solution to be poured off. The writer

has not found that this cloudiness does any harm. The developer keeps well and in fact improves with use, giving richer prints when it has been used for some time than when it is fresh; hence used developer should not be thrown away but may be kept up to normal bulk by adding fresh stock solution from time to time, the clear yellow solution being poured off for use from the mud which settles at the bottom of a used developer.

Some writers recommend development by floating the print face down on the oxalate solution, but the writer prefers to immerse the print bodily in the bath. In ordinary circumstances it is not necessary to take special precautions to flow the developer evenly over the print, since if development is continued as far as it will go no development marks will show, development proceeding as far as the light action calls for and then stopping. For special results, however, a hot developer is sometimes used (normal development takes place at room temperature, that is, 65° to 80° Fahrenheit), and in the event of using hot developer care must be taken to avoid irregular application, since in this case development marks will show; so when the developer is hot it must be flowed over the print with an even sweep exactly as in developing a plate.

Any air bubbles which may appear on the print during development should be removed with a finger or soft brush, as if this is not done they will leave white spots in the finished picture. Development will be complete in from ten seconds to two minutes, depending on the temperature of the developer and the paper used, rough papers requiring somewhat longer develop-

ment than smooth. If it is desired to arrest development before complete this may be done, though in such cases it is practically imperative to retard the action of the developer, as will be explained later, since otherwise it is difficult to work with sufficient rapidity. When development is complete the print is lifted from the tray, drained slightly and placed in a bath of

Water	60 ounces
Hydrochloric acid C. P.	1 ounce

and allowed to remain there for about five minutes, when it is transferred to a second acid bath for the same length of time and then washed in running water for half an hour or so and either hung up to dry or placed between blotters under slight pressure.

Less Contrast.—To obtain less contrast than normal the print should be given less exposure than would ordinarily be the case and be developed in a hot solution, the temperature of the solution depending on the effect desired, for the hotter it is the less will be the contrast. In extreme cases the temperature of the solution may be raised as high as the boiling point, and it should be noted that increase of temperature gives warmer tones in the finished print.

Softer results may also be obtained by adding a very slight amount of hydrochloric acid to the developer, a few drops of the 1:60 clearing bath in sixteen ounces of the oxalate solution having a noticeable effect.

More Contrast.—The variations possible in the direction of increased contrast are greater than in the direction of diminishing contrast, and numerous methods are available, the simplest being to dilute the developer, a slight increase of exposure being then

necessary. If, however, more than five volumes of water are used to one volume of stock solution a certain granularity of the print is likely to result. This granularity may also be a result of using the developer too cold. If insufficient contrast is obtained in this manner the stock solution may be diluted with an equal volume of glycerine instead of water and the print be exposed considerably longer than for normal results. The glycerine slows the development markedly, so that full development may require from five to ten minutes, but instead of permitting the print to develop fully it is taken from the developer just before the desired depth has been reached and is drained slightly, rinsed under a rather vigorous stream of water and placed in the clearing bath. If rinsing is omitted the clearing bath will penetrate the developer irregularly so that development is arrested in places while it continues in other areas, and uneven or streaky results follow. This method is so uncertain and so difficult to gauge accurately that the writer prefers not to use it. A method which seems decidedly preferable to diluting the developer with glycerine is to add to the stock developer a slight amount of potassium bichromate, five grains of the salt to sixteen ounces of the developer producing a marked effect, and further additions increasing contrast to practically an unlimited extent. Printing must be deeper than normal in proportion to the amount of bichromate added. It should be noted that although a diluted developer continues to work as well after use as when fresh the bichromate becomes exhausted with use and fresh additions to the solution must be made. Great increase of contrast may be

secured in the following manner, which will give a normal result from a mere ghost of a negative and practically a silhouette from a normal plate. Printing is continued until the entire print shows a bronze color or even until reversal has taken place, the shadows appearing lighter than the lights, and the print is then developed in clear water, cold water requiring deeper printing and giving more contrast than hot. This method is almost certain to produce granularity of the print, which may or may not be desirable.

WARMER TONES.—As has been stated above, a slight increase in warmth of tone is secured by using a hot developer, and commercial papers may be obtained in which the sensitizing has been such as to give sepia prints. The writer, however, prefers to use the black papers and secure warmer tones by modifying the developer, since the shadows of a print on sepia paper are apt to look rather thin and uninteresting, whereas very desirable rich effects of any desired warmth may be obtained on the regular black papers. The addition of a slight amount of bichloride of mercury to the developer produces a warm black, and further additions may increase the warmth of color up to a full sepia. Of course, the amount of the salt added will depend on the effect desired by the worker, and it will be well to begin with twenty grains of the bichloride to sixteen ounces of the stock solution and proceed from this. Some writers say that the addition of bichloride of mercury causes instability of the results, but the writer has not found this to be the case in his own practice, which extends over a period of about ten years. It is, of course, admitted that this is too short

a time to determine by observation whether or not a print is permanent, but it has been stated on the authority of von Hübl that the image in a mercury developed platinum print consists of pure metallic platinum, the warmth of color being due to a difference in the size of the grains of metal deposited. This seems a probable explanation, and if it is correct there is, of course, no reason to fear fugitiveness of a brown or sepia platinum. The writer believes that when mercury-developed platinum prints prove unstable this instability is due to insufficient clearing, so that some iron salts are left remaining on the paper, these salts of course darkening when exposed to light. This belief is supported by the fact that most writers recommend clearing such prints for not more than two minutes in a single bath of

Water	300 ounces
Hydrochloric acid C. P.	1 ounce

since it is undeniably the case that a normal clearing bath will remove some of the warmth resulting from the use of mercury. Evidently since this is so, if the normal clearing bath is to be employed more of the bichloride must be used to secure a given warmth of tone than when the weaker acid bath is to be employed.

Colder Tones.—Colder tones may be secured by using a developer made up as follows:

Water	16 ounces
Potassium oxalate	3 ounces
Monobasic potassium phosphate	1 ounce

Printing must be slightly deeper for this developer than for the normal solution and a slight increase of contrast will result.

Old Paper.—Platinum paper as sent out by the makers is always contained in a sealed tin tube with preservative as noted above and should always be kept in this manner when not in actual use. If the paper is not kept dry it deteriorates rapidly and even when carefully packed it will deteriorate in time. Stale paper if treated normally gives muddy prints having degraded lights, even the edge of the print which is protected by the rebate of the printing frame being considerably darker than the paper base. The extent of this degradation depends on the age of the paper and it is generally considered that paper six months old will not give the character of print desired by commercial photographers. The degradation of the lights which results from age may, however, be very pleasing for pictorial purposes, especially if bichloride of mercury is used in the developer, but if bright prints are desired they may be secured on paper which has deteriorated to only a slight extent by using glycerine in the developer and arresting development before it is complete, as explained above. If the paper is too old for this it may still be made to give bright prints by the use of bichromate of potash in the developer, the amount of the salt required depending, of course, on the age of the paper. This chemical is capable of producing such an increase of clearness that the writer has made prints of snow pictures with strong sunlight (than which no effect demands greater brilliance) on platinum paper which was nearly two years old.

General Remarks.—A platinum print should appear slightly lighter in the developer than is desired in the finished result, since it dries a little darker than it

appears when wet. If it is desired to restore the brilliance which the print has when wet this may be accomplished by varnishing the dried print, various substances being used for this purpose. French picture varnish thinned with alcohol will give a lustrous surface without changing the color of the print, as will also a bath made up of

Water	16 ounces
Gelatine	½ ounce

The gelatine must be swelled in cold water and dissolved by gentle heat, and the print is dipped into it while the solution is still warm, and is then hung up to dry. The amount of lustre added by this method depends on the temperature of the gelatine solution, since if this is allowed to cool a heavier deposit forms on the print than if the bath is used hot. If a slight increase of warmth in the lights and half tones is not objectionable—and it is often desirable, especially in portraits or in sunny landscapes—the print may be varnished with Johnson's or Old English floor wax applied with a rather stiff brush, the wax being polished with a nail brush or small scrubbing brush. Butcher's Boston Polish may also be used, but imparts a decidedly pink tint to the print, whereas the other polishes give a pure yellow, the Old English being deeper in color than Johnson's. A very desirable increase of richness is secured by applying floor wax to the print and either melting it in over a gas flame—taking care not to set it on fire—or ironing it in with a hot flat iron, in which case the print should be laid face down on a clean piece of paper and the iron applied to the back.

It has been said that the writer does not approve

of using glycerine in combination with brief development to secure increase of contrast, but the treatment with glycerine undeniably gives richer blacks and a more beautiful quality than is obtained with the normal developer. In using it for this purpose development should be allowed to proceed until complete and it should be noted that a glycerine-diluted developer does not keep if heated above 140° Fahrenheit.

Platinum paper may be bought in cut sizes, twelve sheets in a package, or in rolls, a full roll being twenty inches wide and twenty-six feet long, as well as in half rolls, twenty inches wide and thirteen feet long. For the small worker it will be more convenient to buy it in cut sizes, but if any considerable amount of work is to be done it is cheaper to buy the rolls and cut them to size as desired. It is distinctly worth while to save waste platinum prints and clippings of the paper, since these may be refined and the refiners will normally pay at least twenty-five cents per pound for such waste. Used developer also contains a certain amount of platinum and may be sold, in addition to which the clearing baths contain platinum enough to make it worth while saving them if a large amount of work is to be done, as in commercial establishments, but for the average amateur the cost and trouble of recovering the platinum from the acid would amount to more than the value of the metal recovered.

Some workers experience great trouble with "comet marks," that is, small white streaks which appear during development and cannot be removed except by spotting the finished print. The writer has never had any difficulty of this sort except in a few minor in-

stances, but observation leads him to believe that it arises from one or more of three causes. A saturated solution of oxalate of potash will become super-saturated through evaporation of the water during exposure to the air, and some of the salt will crystallize out and fall to the bottom of the bottle, together with other chemicals, the latter being removed from the paper during development. If the bottle is shaken or if the solution is not carefully decanted some of these crystals will be carried into the developing tray and may conceivably cause marks. The second cause is the use of dirty trays, some chemicals remaining in the trays from former work. All trays, for whatever purpose they are used, should be given a thorough scouring with Gold Dust before being put away. The third cause is the formation of a scum on the surface of the developer in the tray. This may be broken up by rocking the tray just before immersing the print.

HAND-SENSITIZED PLATINUM.—The operation of sensitizing platinum paper is an exceedingly simple one, being within the capacity of any person who will follow instructions with even moderate care.

Almost any paper may be used for sensitizing, though some papers will be found too absorbent and others too heavily sized. Papers which can be recommended are the Strathmore Drawing, Charcoal, and Detail papers of the Strathmore Paper Co., the various grades of Japanese vellum and hand-made Spanish papers sold by the Japan Paper Co., of New York City, as well as various writing and note papers. Of course, the possible variations of color and texture are almost unlimited.

Three stock solutions are required, as follows:

1.	Water (hot, distilled)	2 ounces
	Oxalic acid	16 grains
	Ferric oxalate (fresh, green scales)	240 grains
2.	Water (hot, distilled)	2 ounces
	Oxalic acid	16 grains
	Ferric oxalate (fresh, green scales)	240 grains
	Potassium chlorate	4 grains
3.	Water (hot, distilled)	2⅝ ounces
	Potassium chloroplatinite	219 grains (½ ounce)

These should be kept in amber bottles or in the dark, since they are sensitive to light. For use they are mixed in the proportions given below, a medicine dropper or a minim graduate being used for measuring. If a medicine dropper is used it should be washed in clean water after measuring each of the solutions, and some workers prefer to keep three droppers, one for each solution, the objection to this method being that it seldom happens that two droppers measure drops of the same size. If three droppers are used, they should, of course, be checked by means of a standard graduate. It will be seen from what follows that increasing the proportion of Solution 2 increases contrast in the print, and it is possible to get very soft prints from a strong negative or very strong prints from a flat plate by varying the proportions. Reading over these formulæ it will be apparent that the chemical which operates to increase contrast is potassium chlorate and in extreme cases further additions of this salt may be made. In preparing the solutions care should be taken to see that the iron salt is ferric and not ferrous, and this salt should have the form of dry, bright green scales; if the scales are brown or show any tendency to stick together the sample should be rejected. Care should also be taken to see that the potassium chloroplatinite is ob-

tained, and this should be in the form of bright red crystals, the chloroplatinate, which is yellow, not being useful for this purpose.

The paper to be sensitized should be cut about one inch larger each way than the finished print is to be, and is then pinned by the four corners to a horizontal board. The proper quantity of each solution is measured out according to the result desired, as indicated in the following table:

A. For very soft prints.

1.	22 minims
2.	0 minims
3.	24 minims

B. For stronger prints.

1.	18 minims
2.	4 minims
3.	24 minims

C. For average results.

1.	14 minims
2.	8 minims
3.	24 minims

D. For strong prints.

1.	10 minims
2.	12 minims
3.	24 minims

E. For extreme contrast.

1.	0 minims
2.	22 minims
3.	24 minims

These solutions are then mixed thoroughly in a graduate and poured on the paper, being spread by means of a damp brush which is worked back and forth over the surface of the paper until the latter begins to show signs of surface-drying, when it is allowed to remain for about five minutes and is then made bone dry over a stove or gas jet, care being taken that it is not scorched. It should be noted that the sensitizer will scorch before

the paper does so, this fault as a rule not being observable until the print is developed, when it shows as patches darker than they should be. After drying the paper is trimmed to size and stored in a platinum can with preservative until it is to be used.

The processes of printing, development, clearing, and washing are the same as with the commercial papers, except that the hand-sensitized paper prints more slowly than the commercial and that the image is less clearly visible.

Any flat camel-hair or sable brush may be used for sensitizing, though most desirable are the flat Japanese paint brushes. It will be found that after several prints have been sensitized the brush contains enough sensitizer to treat another small piece of paper and this should be done in order to save as much of the platinum salt as possible. The chief point of importance is the drying of the paper, which for most papers should occupy not less than five nor more than ten minutes, though it will be found that some very soft papers will tend to give degraded lights unless dried more rapidly than this, and that with some heavily sized papers it will be necessary to dry them more slowly in order to keep the sensitizer from washing off in the developer. A platinum sensitizer is unlike a gum coating in that there is practically no danger of getting a streaky result. If several pieces are to be sensitized it will be more convenient to obtain the paper in large sheets and sensitize it in that form, afterward cutting it to size, rather than to sensitize each piece separately. Some papers, such as the softer vellums and the hand-made Barcelona paper, will require sizing if multiple prints are

to be made, but this is not generally the case with drawing or writing papers. If, however, it is necessary to size, a thin starch paste may be brushed over the paper after the first print has been developed, cleared, washed and dried, this size being allowed to dry thoroughly before applying the second sensitizer.

It will not be easy to get rich blacks with a single sensitizing, but with two applications of sensitizer this may be accomplished, and the second sensitizer may be put on immediately after drying the first or if preferred the paper may be printed, developed, cleared, washed and dried and the second application of sensitizer take the form of a second printing, it being of course necessary to register the print and to expose by time. Various methods for securing registration are given in the chapters on gum, gum-platinum, and carbon printing. Of course, the second printing may be the same quality as the first or may be either lighter or darker according to the result desired, and if it seems best a different sensitizing mixture may be used for the second printing.

Especially beautiful are prints on various tissues, but these are exceedingly difficult to handle, since it is not easy to observe either the depth of printing or the manner in which development progresses, so that little can be told about the result until the print has been dried and ironed. It is therefore practically imperative to print by time when using such papers, and in most cases a tissue will require sizing before the first sensitizing, though this does not hold good of the vellum tissues.

During the war, commercial platinum paper disappeared from the market, owing to the scarcity of that metal, and its place, so far as pictorial work is concerned, was taken by palladium paper, this being sensitized with salts of palladium, a metal allied to platinum.

Palladium paper gives results which are practically identical with those afforded by platinum, except that it is difficult if not impossible to secure a cold black tone; the image is either of a neutral black or has a slight warmth. This, of course, is no disadvantage except for snow scenes, mist, and the like, and in the case of portraits and summer landscapes is a positive advantage.

In manipulation palladium is almost the same as platinum, the chief differences being that it does not keep quite so well before use (the finished results are equally permanent), that the image does not print out quite so distinctly, and that different developing and clearing baths are employed, as follows:

Developer:	Water	35 ounces
	Sodium citrate	10 ounces
	Citric acid	1 ounce
Clearing bath:	Water	120 ounces
	Sodium citrate	4 ounces
	Citric acid	½ ounce

These solutions are used in the same manner as the corresponding ones for platinum paper.

Since this book was written, commercial platinum paper has disappeared from the American market, a circumstance which is to be regretted, since in spite of marked improvements, no American bromide or gas-light paper can compete with platinum in beauty. Commercial platinum paper can still be obtained, however, from The Platinotype Company, Ltd., 66, High Street, Penge, London, S. E. 20, England; and, of course, the materials for hand-sensitized platinum are still available in the United States.

CHAPTER XI

TECHNIQUE OF CARBON

THERE is a popular impression to the effect that carbon is a difficult process to handle, but this is by no means the case, for although it is more laborious than platinum, it does not require any high degree of manipulative skill, and calls for less actual labor than gum, oil, or photogravure.

THEORY.—If a colloid substance such as gelatine, gum arabic or albumen is sensitized with potassium, sodium, or ammonium bichromate and, after drying, is exposed to light, the colloid becomes insoluble in water. If a dry pigment is incorporated with the colloid and a thin film is spread on a sheet of paper, this film being sensitized and printed under a negative, then, on washing in water, the portions which have been acted on by light will resist the action of the water and remain on the paper, holding their quota of pigment, but those portions which have been protected from light, being soluble, will wash off the paper, taking their pigment with them. Hence there results a print in which the gradations are represented by varying thickness of colloid and pigment.

In carbon printing the colloid used is gelatine, and, since this is in no case soluble in cold water, hot water (about 110° Fahrenheit) must be employed for developing.

THE TISSUE.—The term "tissue" is rather a misnomer, since the paper supplied for carbon work con-

sists of a stout backing which carries a heavy film of gelatine and pigment, the whole being stiff and, when dry, brittle. The tissue is supplied in forty or more different colors, and may be bought either in cut sizes (5×7, $6\frac{1}{2} \times 8\frac{1}{2}$, and 8×10 are the only sizes supplied) or in rolls thirty inches by twelve feet. If much work is to be done the rolls are somewhat cheaper, but the cut sizes are easier to handle, since they are packed flat and have less tendency to curl. The tissue should be either bought or cut at least an inch larger each way than the negative to be printed from, this being imperative for multiple printing (as will be seen later) and advisable in any case, since if the tissue is cut to size just before printing it is less likely to give trouble by frilling during the subsequent manipulations than if the edge has been cut for some time.

Sensitizing by Immersion.—Formulæ innumerable are given for sensitizing, but the one which the writer finds most desirable is the following, slightly modified from that worked out by Henry W. Bennett:

Water, hot	30 ounces
Potassium bichromate	960 grains
Dissolve, and when cool add	
Citric acid	240 grains
When dissolved add, a little at a time, with stirring,	
Stronger ammonia....q. s. to turn from orange to yellow.	

Add water to make total bulk 64 ounces. Bottle and leave uncorked for twenty-four hours to allow any excess of ammonia to pass off. Use between 60° and 75° F.

This sensitizer keeps indefinitely, but should be filtered after use. To sensitize, pour an inch or so of the solution into a tray and immerse the tissue, face up, breaking any air-bubbles that may form on either front or back, and keeping the tissue completely immersed. At the expiration of two and a half minutes from the

THE STYGIAN SHORE
BY H. Y. SÜMMONS
From a Carbon Print

first immersion withdraw the tissue, lay it face down on a clean piece of glass or a clean ferrotype plate, and squeegee lightly to expel the excess of sensitizer. A scraper squeegee should be used instead of a roller, and the kind sold for cleaning windows is the best, the photographic squeegees being too stiff. If glass is used the tissue should be stripped off and hung up in the dark to dry, but if the ferrotype plate is employed the tissue may be allowed to dry on it, and this is recommended, since the tissue will then be less likely to curl, and, the surface having been protected from air while drying, the tissue will be in better working condition. When dry the tissue will strip from the ferrotype plate very easily, provided the plate was clean, though dirt or finger-marks may cause it to stick. Sensitizing may be done in an ordinary room, since the tissue is not sensitive until dry, but drying should take place in the dark, for when dry the tissue is at least as sensitive as P. O. P. If the atmospheric conditions are such that drying requires more than eight or ten hours the tissue may show a tendency to become insoluble without exposure to light, and in extreme cases may be quite useless. The sensitized tissue does not remain in first-class condition for more than twenty-four hours, and in the course of a week or ten days becomes entirely useless through insolubilization, even though protected from light and air in a platinum tin, with preservative. Without this precaution deterioration is more rapid.

Longer immersion or a stronger bath gives a quicker printing tissue and softer prints, briefer immersion or a weaker bath giving a slower tissue and more contrast,

but these variations are not recommended, since the results are somewhat indeterminate. The normal bath is a 3 per cent. solution, and the sensitizer should in no case be weaker than 1 per cent. or stronger than 7 per cent.

BICHROMATE POISONING.—Some individuals are sensitive to bichromates, contact with these salts producing an annoying and sometimes painful skin irritation, which in extreme cases may be very serious. The writer has never experienced any trouble from this source, but is acquainted with a photographer who suffered for more than a year with a recurrent skin eruption covering the hands, forearms, and part of the face, this eruption being so serious as to prohibit absolutely all photographic activity and almost to incapacitate the individual from any work whatever. Should the carbon worker notice any swelling, redness, or soreness of the fingers, especially around the base of the nails, he should at once abandon the use of bichromate and consult a skin specialist. However, the use of rubber gloves is a certain preventive of trouble, and is to be recommended, since no one can tell whether or not he is sensitive except by experience

QUICK-DRYING SENSITIZER.—It will be seen that unless sensitizing is done early in the morning it will not be possible to print on the same day if the tissue is sensitized by immersion, but it is possible to sensitize in such a manner that the tissue will dry within half an hour or an hour, by means of a quick-drying sensitizer. This may be prepared by the worker, but it is better to obtain the commercial solution. To use this sensitizer the tissue is fastened face up on a piece of

glass by means of wooden clips, the sensitizer is poured to the depth of half an inch or so into a tray and is applied to the tissue by means of a Blanchard brush. This consists of a piece of glass with a double thickness of canton or outing flannel folded over one edge and held in place by a string or rubber band. The brush, which should be as long as the long way of the tissue, is dipped into the sensitizer, drained, and drawn several times over the tissue, alternating downward and cross strokes. Firm but not heavy pressure should be used, and if a definite number of strokes is adhered to the printing speed of different pieces of tissue will be alike. The chief danger in brush sensitizing is that streaky prints will result from having the brush either too wet or too dry, and only experience can determine the proper condition. Any unused sensitizer remaining in the tray should be thrown away.

Should the worker desire to prepare his own spirit sensitizer the following method will be found satisfactory.

Stock solution:	
Water	4 ounces
Sodium bichromate	1920 grains
For use take:	
Stock solution	2 drams
Alcohol 95 per cent to make	2 ounces

More or less of the stock solution may be used in order to decrease or increase contrast.

PRINTING.—The printing time must be determined by some other means than inspection, since carbon does not give a visible image in the printing frame except in the case of some of the lighter colors, the image even then being too indefinite to serve as a guide.

Various forms of actinometer are recommended by different authors, but the present writer finds the simplest method—which is quite satisfactory—to be to make a proof on P. O. P. and to print the carbon tissue for the same time as is required for proofing. This is not quite accurate, since the speed of various batches of P. O. P., even those of the same brand, may vary considerably, and different tissues have different printing speeds, but carbon fortunately has a good deal of latitude, and even serious errors of exposure may be corrected in development. The mezzotint tissues should be printed only half this time, and the Ivory Black only three-quarters, but this method will serve as a guide, and will be found reasonably accurate, at all events in the case of the black tissues.

Since the print must be transferred to another sheet of paper (or other support) for development, it follows that it will be reversed as regards right and left if printed in the usual manner. Of course, if the negative is on film or paper it may simply be put into the frame backward and the tissue placed in contact with the back, when the finished print will be the right way round. If the negative is on a glass plate and the print is made from the back some softening of outlines will result if printing takes place in a diffused light, that is, on a dull day or in the shade, but if direct sunlight is used and the frame is not moved during exposure diffusion will probably not be apparent.

In order that the print may develop satisfactorily, without frilling, it is necessary to provide a safe-edge, that is, a strip of the tissue one-eighth inch or more in width around the margin must be entirely protected

from light, and this may be done by the rebate of the printing frame, by a line of opaque run around the edge of the negative, by a strip of passepartout tape gummed to the plate, or by a cardboard mask. The writer's own practice is to depend on the rebate of the frame in single printing and in multiple printing on a mask, the mask also furnishing a very convenient means for insuring registration of the successive prints. Whatever the form of the mask, it is desirable that it be separated from the tissue by about one-sixteenth inch, a slight vignetting action facilitating the subsequent operations.

Need for Transferring.—Since the effect of printing is to render the gelatine insoluble in inverse proportion to the densities of the gradations of the negative, it follows that as the print comes from the frame it has a layer of insoluble gelatine over the entire surface, except perhaps in the highest lights, the insolubilization extending to different depths in the film, depending on the amount of light that has penetrated the corresponding portions of the negative. Therefore it will be difficult for the hot water to penetrate to the soluble gelatine, and having done so, it will detach the entire film from the paper backing except in those portions where the light has acted clear through the film. If, however, the gelatine film is transferred to another piece of paper so that what was originally the outer layer is now next the paper, then the water can easily reach the soluble parts, and will dissolve them away without affecting the parts that have been acted upon by light.

Making Transfer Paper.—The transfer paper

consists simply of a sheet of paper which has been coated with a film of insoluble gelatine, and may be bought already prepared, but the worker is strongly advised to make his own, since he may then choose any color and surface texture desired, and in addition to this he will find the home-made paper more reliable than the commercial.

Making the transfer paper is a simple and easy operation, and is carried out as follows. Any paper which does not disintegrate in hot water may be used, though a rather stout one is preferable to a thin, any gelatine-coated paper having a tendency to curl, this being aggravated in carbon work by the varying thicknesses of the gelatine film, so that a thin paper not only curls but also buckles. The coating solution is

Cold water	4 ounces
Nelson's No. 1 gelatine	60 grains

Allow the gelatine to swell for five minutes and then heat until dissolved. Add a little at a time, with constant stirring

Hot water	4 drams
Chrome alum	12 grains

If the chrome alum solution is cold or is added hastily, or if the gelatine solution is not stirred constantly the gelatine may coagulate, but it will work equally well in that condition, though it is not so easy to use as when liquid. The mixed solution should be strained through several thicknesses of cheese-cloth into a double boiler and should be kept hot while in use. At the end of the day's work the surplus is thrown away. The above quantity will coat approximately three 22″×28″ sheets, depending on the number of coats applied. The gelatine named is relatively expensive,

but not actually so, a pound of it, costing $1.50, having lasted the writer over three years. However, some of the writer's pupils have used ordinary cooking gelatine for this purpose, with perfect success.

It is convenient to prepare the paper in large sheets and cut them to size afterward, but if this is not done pieces at least two inches larger each way than the negative should be coated, since it is necessary that the transfer paper be larger than the tissue. The paper to be coated is pinned by the four corners to a horizontal board, a small, fine-grained sponge is dipped into hot water and squeezed out, and is then dipped into the gelatine solution and rubbed over the paper. The gelatine should be used freely and should be spread over the entire paper, working rapidly and rubbing until the paper begins to show signs of surface-drying, when it may be given a second application and be hung up to dry. By the time the third sheet has been coated the first will be ready for a second treatment, two treatments being sufficient for a smooth paper and three for a rough, a very rough, such as Whatman, requiring four or five. The prepared paper keeps indefinitely without special precautions.

If the sponge is cold enough to chill the gelatine a skin will form, and this may cause a shiny spot on the paper which will show in the finished print. Such a spot may often be removed by vigorous rubbing with the sponge as soon as it appears, but if this does not suffice that portion of the paper should be discarded.

Should the gelatine coagulate on addition of the chrome alum solution it may sometimes be liquefied by raising the temperature, but even if this is unsuccess-

ful it may still be used, though it must then be rubbed into the paper more vigorously than if liquid.

In an emergency a sheet of bromide paper which has been fixed without exposure to light, washed and hardened may be used for transfer paper. To harden, the paper should be given ten minutes in

Water	10 ounces
Formaldehyde, 40 per cent. solution	1 ounce

rinsed and dried. Double transfer paper may also be used for single transfer if hardened in the manner described.

Transferring.—A pencil mark is made on the back of the transfer paper and it is then soaked for half an hour (longer can do no harm) in water about 65° Fahrenheit before the print is transferred, and in the case of a very rough paper it is well to give it five minutes in water at about 140° Fahrenheit just before use. The print should be transferred as soon as the exposure is complete, since bichromated colloids show a phenomenon known as the "continuing action." That is, they keep on printing after removal from light, and this action may result in a correctly exposed piece of tissue being hopelessly over-printed four or five hours after being taken from the printing frame, even if stored in the dark. The continuing action may be retarded by keeping the print under pressure, as in a printing frame, or by storing it in a platinum tin with preservative, and may be completely arrested by washing the print for half an hour in cold running water.

The transfer paper having been properly soaked (care having been taken to see that no air-bubbles adhered to it and that the coated side did not float out

of the water, either of these circumstances being likely to cause blisters or tearing of the print) it is placed face down in a tray of water at about 65° Fahrenheit. The print is taken from the frame and is placed face up in the same tray, being completely covered with water and air-bubbles being removed. The tissue will at first tend to curl up, film side in, owing to the fact that the backing absorbs water more rapidly than the gelatine, and it must be pressed down under the surface of the water. The tissue will gradually flatten out, and if left for five or ten minutes would curl the other way. Just before it flattens out, however, the transfer paper is turned face up and the tissue face down, the two being brought together under water, film to film. They are lifted out together, drained for two or three seconds, and laid on a piece of glass, tissue uppermost. The tissue is held in place with the fingers of one hand and the squeegee is applied, lightly at first to expel any air-bubbles which may be between them (since these would cause blisters in the finished print) and then more firmly, to expel the water and bring the two films into close contact. It is well to start slightly beyond the middle and work toward one end, afterward reversing the glass and working toward the other end, for bubbles thus have a shorter distance to travel than otherwise. Squeegeeing being finished, a sheet of blotting paper is laid over the print and the two are left under pressure for half an hour or so to insure firm cohesion of the gelatine films. The writer generally uses six or eight old 14×17 negatives to furnish the required pressure, but in the case of a very rough transfer paper it will be well to use half a dozen sheets of

blotting-paper and screw the whole up in a copy-press.

STRIPPING.—It is necessary that the backing paper be stripped off in order that the hot water may reach the gelatine, and this is accomplished in the following manner: The transfer paper with the adhering tissue is taken from under pressure, bending it as little as possible, and is slid, tissue uppermost, into a tray of water at about 100° Fahrenheit. Air-bubbles are brushed off, and after a minute or two the pigment will probably begin to ooze out from under the edges of the tissue. Should this not occur the temperature of the water may be raised gradually by successive additions of hot water (lifting the print from the tray while adding the hot water) with a little wait after each addition, until oozing takes place. After the pigment has oozed for a minute or two one corner of the tissue may be lifted with a finger-nail, grasped between thumb and finger, and stripped off. An even pull, without stopping, and keeping the transfer paper with the adhering print under water, are generally said to be necessary, but the writer finds that this technique, though advisable, is not imperative. The backing paper may be thrown away or may be saved for the sake of the portion of the film which remains on it, this being useful for spotting the finished print.

DEVELOPMENT.—No suggestion of the picture will show on the transfer paper at first, the print appearing simply as a slimy, dark-colored film, with irregular patches. The transfer paper is grasped at one end and shaken back and forth under the water, when the gelatine and pigment can be seen floating off, and the picture will gradually appear. Development should continue

until the picture is slightly lighter than it should be when finished, since it dries darker than it seems when wet, and if necessary the temperature of the water may be raised, since hot water will dissolve more of the gelatine than will tepid. The tissue should be so printed that development may be completed at 110° Fahrenheit, since a higher temperature than this is likely to cause blisters or frilling, though the writer has, in extreme cases, raised the water to 140° Fahrenheit. Such radical treatment, however, presupposes perfect technique in preparing the transfer paper and in transferring and stripping. Should the print fail to develop satisfactorily at 120° Fahrenheit a small amount of alkali, *e. g.*, stronger ammonia, sodium carbonate, or sodium bicarbonate, may be added to the developing water, perhaps a teaspoonful to a quart of water, but the use of an alkali is very likely to cause blisters or frilling. Care should be taken that development continues until no irregular dark patches remain on the print, though if these are due to uneven sensitizing rather than to incomplete development it will be impossible to remove them. Most writers recommend the use of an alum bath for clearing and hardening, but hardening is not necessary unless multiple prints are to be made, and the slight amount of bichromate remaining in the film will not be perceptible unless a white transfer paper is used. However, if it is desired to clear the print, it may be given five minutes in a 5 per cent. solution of powdered alum, being afterward rinsed in three or four changes of cold water and hung up to dry. Whether the clearing bath is used or not the print should be rinsed.

Local Modifications.—Should portions of the print be too dark for the desired pictorial effect they may be raised in value while in the developing water by brushing lightly with a tuft of cotton or a camel-hair or sable brush, or by directing a stream of hot water on them, but this work should be done gently and cautiously or the film may be torn, this being especially likely to happen if development has been forced by means of an alkali. Local values may be raised in the dry print by means of a hard pencil eraser. Should it be desired to darken an area this is best done on the dry print by softening a little piece of unexposed tissue in warm water and applying the softened gelatine and pigment to the print with a brush, this method being especially useful for spotting.

Multiple Printing.—In multiple printing a single print is made in the usual manner and hardened, and a second or even third or fourth print is superposed on it. The second print may, of course, be either in the same tissue as the first or in a different one, and may be either lighter or darker than the first print, or of the same quality. There is practically no limit to the number of printings that may be given, the writer having superposed five printings of Ivory Black on one of Red Chalk, to get a special effect. If different colors are used, care should be taken to avoid such as are complementary, since the combination of these will give black. Thus, an attempt to print a sunset sky in red and the landscape in green will result in a warm black sky and a cool black foreground, unless, of course, each portion of the negative is shaded while the other is being printed.

Registration.—Some means must be employed to insure that the outlines of the second print coincide with those of the first, and the simplest method which the writer knows is as follows: A printing frame a size larger than the negative, and fitted with a plate glass, is used. A cardboard mask is made, as shown in Figure

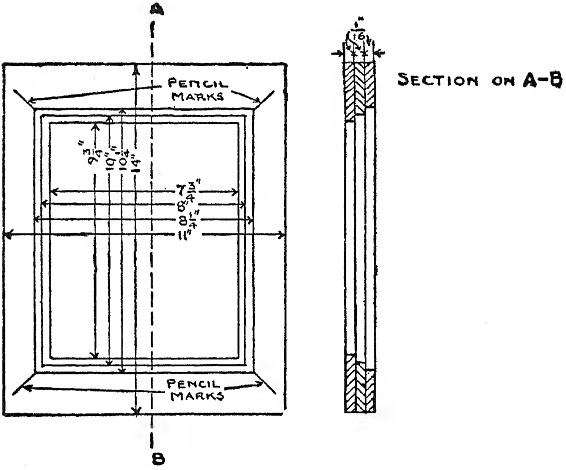


Fig. 41.

41, the dimensions given being for an 8×10 plate, since the worker can easily modify them for his own size of negative. The mask is made of three pieces of cardboard with rectangular openings, as shown, the pieces being firmly glued together. The $8\frac{1}{4}'' \times 10\frac{1}{4}''$ piece cut from the third card should be saved. This mask is placed in the printing frame, being supported

by the plate glass, and the negative is laid in the second opening, which should be of such size that the plate fits it snugly. Plates vary somewhat in size, and one which is small enough to move perceptibly in the opening may be wedged with small slivers of wood. The sensitized tissue is cut to fit snugly in the $8\frac{1}{4}'' \times 10\frac{1}{4}''$ opening, is placed in it, the corresponding piece of card is placed on the tissue to insure perfect contact with the negative, and the back of the frame is clamped in place.

The writer's original method called for a two-ply mask, pencil-marks serving as guides for registration, and the addition of the third piece, which holds the tissue, was the suggestion of one of the writer's pupils. Obviously, however many prints are made in this manner, the outlines of the negative and the edges of the tissue will always be in the same relative position, and if steps are taken to insure placing successive pieces of tissue in the same relative positions on the transfer paper, the printings must register. Guide marks are made on the transfer paper with a fine-pointed B or 2B pencil, as shown in Figure 42, this being done after the tissue has been squeegeed to the transfer paper, and either before putting the two under pressure or just before stripping. Stripping and development proceed in the usual manner, but the finished print should be hardened before putting to dry, hardening being advisable though not imperative. Hardening is best accomplished by soaking the print for ten minutes in

Water....................................	10 ounces
Formaldehyde, 40 per cent. solution.........	1 ounce

A 10 per cent. chrome alum solution may be used, but

the formaldehyde is preferable, since formaldehyde is an aqueous solution of a gas, which is driven off by drying, whereas chrome alum, unless thoroughly washed out of the film, may cause reticulation of the second print. The second and subsequent prints are registered with the negative exactly as the first, and in applying them to the first print this is soaked just like a new piece of transfer paper, the corners of the second

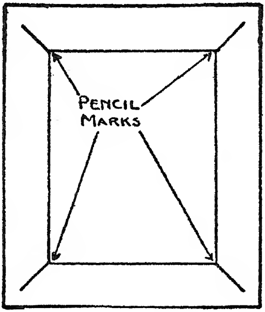


FIG. 42.

print being made to coincide with the pencil marks before squeegeeing. It may be that the second print will swell to a size different from that of the first, or that the paper carrying the first print will not expand to its original size, and in this case the only thing to do is to register as nearly as possible, since the variation is not likely to be of importance in pictorial work. Stripping and development of the second print proceed as in the case of the first.

FAILURES.—It is not possible to give, in a book the

size of the present one, a complete list of all the causes of failure that may occur in carbon work, since such a list would occupy too much space; but this fact need not deter the amateur from taking up carbon printing, many of the faults in question being unlikely to occur. Still, a few of the more usual ones may be mentioned.

Tissue which has dried too slowly or has been kept too long after drying will give degraded lights, and may refuse to adhere to the transfer paper; failure to adhere, either all over or in spots, being also due at times to insufficient soaking of the transfer paper or excessive soaking of the tissue before squeegeeing, to insufficient pressure, or to an attempt to transfer to the uncoated side of the transfer paper.

Air-bubbles on either tissue or transfer paper, at any stage of the work, may cause blisters, and these may also result from the use of water at too high a temperature or of alkali.

Frilling or tearing may be caused by the use of a tissue with old edges, by undue haste or roughness in stripping, by serious over-printing, or by the fact of the tissue overlapping the edge of the transfer paper.

Using the sensitizer below 60° Fahrenheit may cause reticulation of the film and if the sensitizer is above 75° Fahrenheit the gelatine may be softened, even, in extreme cases, melting. Hence, if the room temperature is 80° Fahrenheit or more, it is advisable to chill the sensitizer and the ferrotype plate.

Grease may cause blank spots on the print, or even blisters, the chief danger from this cause lying in finger marks, this circumstance furnishing an additional reason for using rubber gloves.

CARBON TISSUES

General Remarks.—It may be thought, from the long and apparently complicated description of the process, that carbon printing is difficult, but this is by no means the case. The writer has heard of an expert carbon printer who, starting with the sensitized tissue, finished two hundred prints in a day, this being far in excess of what any pictorial worker will wish to make.

If it is desired to have the print the right way around, and to have precise definition, double transfer may be resorted to, in which the print is first transferred to a temporary support, where it is developed, and there retransferred to a final support. The writer, however, has never found this method to possess any advantages for pictorial work, and it unquestionably has several disadvantages, since it adds an extra process—the most delicate of all—and limits the possibilities in the matter of texture, the only surface possible in double transfer being a smooth one. Of course if an enlarged negative is to be used it may be reversed at the time of enlarging, but the diffusion resulting from printing from the back of the plate is not likely to be in excess of that desired by the pictorial worker.

Speed and Scale of Carbon Tissues.—The various carbon tissues render widely different scales of gradation and print with different speeds. The writer has never seen any definite information bearing on these points, and feels that something of the sort would be valuable to pictorial workers, both in enabling them to adjust the printing time with, in consequence, a possible saving of material, and also in making it possible for them to select the carbon tissue which will best render the negative in question or to make the

negative to suit the tissue to be used. Of course, the selection of the tissue does not depend merely on the scale of the negative, since the color to be used for printing is of importance, but it often happens that there is a possibility of choice among several tissues, for there are five different blacks and there are also other tissues of very similar character.

The experimental work involved in making up the table given below was done by one of the writer's pupils, Mr. W. R. Latimer, class of 1915, and was carried out in the following manner: A photometer of forty steps was first made by gluing as many pieces of tracing paper to a glass plate, each piece except the first having in it an opening slightly larger than the preceding one, that is, the first piece was entire, the second piece had an opening $\frac{1}{2}'' \times 1''$, the third an opening $1''$ square, the fourth an opening $1\frac{1}{2}'' \times 1''$ and so on. Thus it will be seen that forty steps differing from one another by slight gradations resulted, and the different tissues having been sensitized and dried as nearly as possible in uniform conditions were printed in this photometer exactly as though the latter were an ordinary negative, a constant light (mercury vapor arc) being used. The printing time in each case was adjusted so that the lower gradations of the photometer were blocked up, and in no case would the tissue register the full number of steps. The steps were of course numbered in sequence, the thinnest being 1 and the densest being 40. Development in each case was in water at precisely 112° Fahrenheit. The scale of the tissue was determined by the number of tints visible in the finished print, the lowest being the first to block

up and the highest the last one which showed a distinct tint on the paper; that is, if 3 and 4 showed no differentiation but 4 and 5 did, four was considered to be the extreme dark of the tissue. This table does not show any relation between the printing speed of the tissue and the printing speed of P. O. P., since, as noted above, the latter varies considerably in speed. Ivory Black was found to be the most rapid printing tissue, and the speeds of the other tissues are indicated in relation to this. That is, if a certain negative requires one minute exposure to print in Ivory Black, it will need one and one-quarter minutes to print in Warm Black. These speeds are approximate only.

Tissue.	Relative Speed.	Scale.
Ivory Black	1	15
Blue Black	1	15
Warm Black	1¼	15
Neutral Ink	1¼	13
Brownish Black	2½	16
Platino Black	1¼	16
Standard Brown	2	16
Vandyke Brown	1¾	18
Portrait Brown	2¼	19
Ruby Brown	1¾	17
Chocolate Brown	3	15
Cold Bistre	1¼	18
Green Sepia	1¾	19
Rembrandt Sepia	1¼	18
Cool Sepia	2¼	16
Sepia	1¼	17
Turner Sepia	2	19
Italian Green	1¼	18
Gray Green	2½	15
Terra Cotta	3¼	18
Bright Mauve	1½	13

CHAPTER XII

CARBRO PROCESS

SOME years ago there was placed on the market a process known as ozobrome, which afforded a means for making true carbon prints from bromide or gaslight prints, without the use of daylight. This process, however, was never commercially successful, partly because of the difficulty of obtaining supplies, partly because of lack of general interest, and partly because no sensitizing formulæ were published, the worker being obliged to purchase his sensitizer ready prepared. For these reasons it was withdrawn after a time, but the method has recently been revived under the name of carbro, complete formulæ being published, and the process offers so many advantages over carbon that it seems well worthy of attention.

Briefly, a sheet of carbon tissue is sensitized by being immersed for a time in the proper solution, and is then squeegeed to a bromide or gaslight print. After remaining for a few minutes, it is stripped and squeegeed to a sheet of single transfer paper, the subsequent proceedings—stripping, development, clearing and drying—being the same as in ordinary carbon work. The printing, that is, the partial insolubilization of the gelatine, results from the chemical reaction between the sensitizer and the silver of the bromide or gaslight image, exactly as in regular carbon work it results from the reaction between the sensitizer and light.

It will be seen that this method avoids the necessity for sunlight for printing; all operations may be carried

out either by artificial light or by daylight, since the carbon tissue is at no point sensitive to light. Also, is makes possible the production of large carbon prints without the need for an enlarged negative, thus eliminating the most delicate item in the making of large prints. Further, as will be seen later, the process is much more flexible than ordinary carbon, far greater variations of total contrast than are possible with carbon being attained with the utmost ease. The only disadvantage which the author has discovered is a slightly greater tendency to frilling during development, but this is not so great as to present any difficulties which cannot be avoided with reasonable care.

The Bromide Print.—A description of the process naturally begins with the bromide or gaslight print, and it will be found that almost any good paper may be used. The easiest to work, however, are the smooth platino-matt surfaces; a lustrous or partly lustrous surface is not so readily handled. Since carbro, like carbon, tends to give slightly degraded lights, it is desirable that the silver print be a trifle higher in key, so far as the lights are concerned, than the finished carbon is to be, and it is imperative that it receive full development; as in sepia toning, if the light-affected silver has not been completely reduced uneven results may be expected. This means that the bromide print should have the minimum exposure which will render full detail in the lights, and that it should remain in the developer for two or three minutes after all action has apparently ceased. It is desirable that the bromide be printed with a white margin, to act as a safe-edge, but this is not strictly necessary; the same result may be secured by cutting the carbon tissue a trifle larger than the bromide

print, and allowing the support on which squeegeeing is done to serve the purpose of a safe-edge.

There are two methods of working, the transfer and the non-transfer. The former presents the advantages of offering a greater choice of final support, since any single transfer paper which is suitable for ordinary carbon work may be used, whereas in non-transfer the final support is the bromide print; and of enabling the worker to produce several carbons from one bromide. The non-transfer offers the advantage of eliminating one operation, thus simplifying the process somewhat. We will first consider the non-transfer method.

Non-Transfer Method.—A suitable bromide or gas-light print having been secured, it is placed to soak in cold water for ten minutes, or until thoroughly limp, air-bubbles being avoided. The carbon tissue is sensitized in a manner to be described later, and the bromide having been lifted from the water and placed face up on a sheet of glass, the carbon tissue is placed on it, face down, and the two are squeegeed into contact. Theoretically, printing starts immediately, and therefore any slipping of the carbon tissue will result in a double image, but in practice the author has found considerable movement to be allowable, particularly if there is a film of water over the bromide print when the carbon tissue is laid on it. The two having been squeegeed firmly but not violently together, they are then placed between two sheets of glass and moderate pressure is applied. It is desirable that slight but not complete drying take place, as this tends to improve the cohesion of the films, so a sheet of blotting paper should be laid on the back of the carbon tissue before the second sheet of glass is placed thereon. The contact having been maintained

for from twelve to twenty minutes—the exact time is not important provided these limits are observed—the bromide print, with the carbon tissue adhering, is lifted from the glass and placed in a tray of water at about 95° Fahrenheit. The water is gradually warmed until oozing of the pigment takes place, when the backing paper is stripped off and development proceeds in the same manner as in regular carbon work. It will in general be found that carbro prints develop at a somewhat lower temperature than ordinary carbon.

FURTHER TREATMENT OF THE SILVER PRINT.—It will be found that the action of the sensitizer has caused bleaching of the silver image, and any one of four courses may now be taken. (a) The silver image may be entirely removed with Farmer's reducer, leaving a pure carbon print. (b) The silver image may be redeveloped to a sepia, using barium sulphide, as described on page 128, thus giving the effect of a multiple print. (c) The image may be redeveloped to a black with any ordinary developer, and kept thus. (d) The image may be redeveloped to a black as in (c), and made the basis for multiple printing.

It may be found that the bleaching has not been complete, some traces of the black image remaining in the shadows, and if (b) is decided on the bleaching should be completed with the ferricyanide and bromide solution before toning. If redevelopment to black is decided on, the print should be immersed for at least fifteen minutes in the developer to insure thorough blackening. Any developer may be used, but amidol is preferred, since this, working without alkali, does not tend to soften the gelatine. If multiple printing is to be carried out, the print should be dried, thus hardening

the gelatine, and resoaked for subsequent printings. Obviously, in this method no registration is necessary; the sensitized carbon tissue is simply squeegeed in place as in the first instance, and the silver image takes care of registration. There does not seem to be any practical limit to the number of printings which can be applied in this manner, but with some papers it may be necessary to harden the gelatine between printings; for this purpose formaldehyde is recommended, as on page 175. If an alkaline developer is employed for redevelopment of the bromide, it must be thoroughly washed out of the print, or frilling of the subsequent carbons may result.

Transfer.—In the transfer method the carbon tissue is sensitized and squeegeed to the bromide exactly as before. After the two have remained in contact for the proper length of time the carbon tissue is simply stripped, dry, from the bromide, and is then squeegeed to a previously soaked piece of single transfer paper and placed under pressure as in ordinary carbon work. The subsequent operations of stripping and development are carried out in the same manner as with regular carbon. If multiple printing is to be resorted to, registration is necessary, and this may be effected very readily by making pencil marks at the corners of the carbon tissue as it lies on the promide print (which should, obviously, be cut larger than the carbon tissue) and also on the transfer paper, after the carbon tissue is squeegeed thereto. By cutting all subsequent pieces of tissue to the same size and registering them with both sets of pencil marks registration of the several images will be insured.

Sensitizing.—There are two methods of sensitizing,

one worked out by Mr. Garon, the other by Mr. Farmer. The latter has been worked out in greater detail, for standard results, whereas the former, though less complete, offers wider possibilities of variation. We will first consider the Garon method.

Make up two stock solutions, as follows:

A.

Water	20 ounces
Potassium bichromate	480 grains
Potassium ferricyanide	480 grains
Potassium bromide	480 grains
For use take	
A	1 ounce
Water	3 ounces

B.

Glacial acetic acid	1 ounce
Hydrochloric acid C. P.	1 ounce
Formaldehyde 40%	22 ounces
For use take	
B	1 ounce
Water	23 ounces

The tissue is immersed for three minutes in the dilute A solution, drained for fifteen seconds, and then immersed for the proper time in the dilute B solution, shorter immersion in B giving stronger prints and longer immersion softer. The precise time in the B bath will depend on the bromide print, the color of the tissue used, and the result desired, but a fair average for the first trial would be twenty seconds. As an example of the variation possible, the author has taken a gaslight print which was excessively strong, the shadows being practically blocked up and devoid of detail. A carbro print was made in Standard Brown, giving ten seconds in the dilute B solution, the result being a normal print, excellently graded and detailed, and not over strong—Standard Brown is rather a soft-working color. Another print was made, giving ninety seconds in the dilute B

bath, and the result, though perfect in detail and gradation in both lights and shadows, was so soft as to be a mere ghost of a print, closely resembling an undeveloped platinum. Of course, there must be some limit to the variation possible by this means, some point where the immersion in the B bath is so prolonged as to wash the sensitizer from the tissue, but for all practical purposes this limit appears to fall beyond any point which would ever be used in ordinary working, so that we may fairly consider the possibilities to be without restriction.

Taking up the Farmer method, we find that though it does not offer so great opportunity for variation in contrast, it has been worked out in somewhat greater detail, the purpose being to secure normal prints with the various colors. The data given below refer to the tissues of the Autotype Company.

Make up three stock solutions, as follows:

A.

Water	20 ounces
Potassium bichromate	400 grains
Potassium ferricyanide	175 grains
Potassium bromide	175 grains

B.

Water	20 ounces
Chrome alum	300 grains
Potassium bisulphate	45 grains

C.

Water	20 ounces
Potassium bisulphate	45 grains

The sensitizing baths are made up as follows, and must be made up at least twenty-four hours before use, allowing them to ripen.

1.

A	1¾ ounces
B	2½ drams
C	1⅔ drams
Water	7 ounces

2.

A	1¾ ounces
B	5 drams
C	4 drams
Water	7 ounces

The following tissues are sensitized in bath 1 for the times given.

Tissue	*Time*
Dark Blue	3¼ minutes
Terra Cotta	3½ minutes
Standard Brown	4¼ minutes
Sepia	5½ minutes
Sea Green	3¼ minutes
Vandyck Brown	5½ minutes
Bottle Green	4 minutes
Italian Green	4¼ minutes
Portrait Purple	3¾ minutes
Red Chalk	5½ minutes

The following are sensitized in bath 2 for the times given.

Tissue	*Time*
Warm Sepia	4½ minutes
Brown Black	5¼ minutes
Rembrandt Sepia	4 minutes
Warm Black	4½ minutes
Ivory Black	5 minutes
Engraving Black	6 minutes
Grey Green	4½ minutes
Green Sepia	4 minutes
Cool Brown Mezzotint	4 minutes

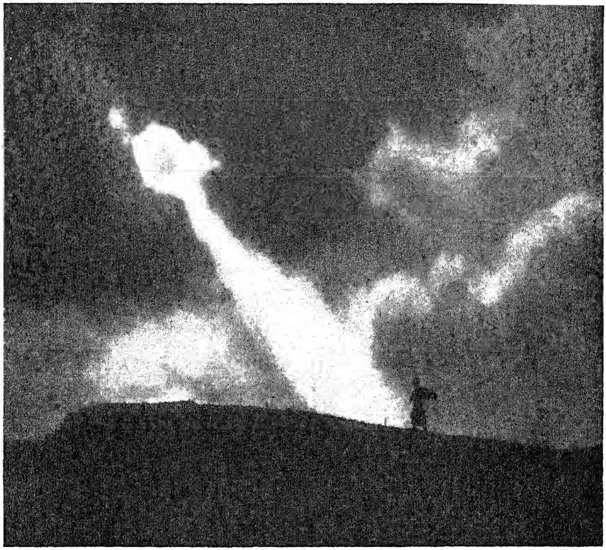
If hard water is used in making up the solutions, it may be necessary to add a slight amount of C to the quantities given for baths 1 and 2. From one-half to one dram will probably be sufficient, one or two experiments being required to determine the exact amount, when a note may be made for future reference. The A, B, and C solutions will keep indefinitely, but the working baths, 1 and 2, become exhausted after a time, and must be thrown away, fresh being made up.

Aside from the failures possible in ordinary carbon

work, there are a few which are peculiar to carbro, but these are readily avoided, with moderate care. Fogged high-lights may be caused by an excess of B solution, or by using the sensitizing bath too fresh. Washing away of high-lights may be caused either by an insufficiency of C solution, or by an exhausted sensitizing bath. Excess of C solution may cause loss of richness in the finished print, but there is not likely to be any trouble from this cause unless the excess is considerable.

Duplication.—If it is desired to produce several carbons from one bromide, this may easily be done by following the transfer method and redeveloping the bromide after each carbon is made. Redevelopment should be continued for at least fifteen minutes, otherwise subsequent carbons are likely to show weak and undetailed lights. If amidol is used for redevelopment a moderate rinsing is all that is necessary, but if a developer containing alkali is employed washing must be thorough, since any alkali remaining in the film may cause frilling or blistering of the carbons. Fixing and drying after redevelopment are unnecessary. The practical limit, due to mechanical causes, appears to be about six carbons from one bromide, though with care this may be increased slightly.

General Remarks.—It will be seen that the carbro process affords an opportunity for the production of prints and enlargements of the highest pictorial quality, without certain of the restrictions hitherto placed on the worker by the limitations of the medium, and the author feels that the process is well worthy the attention of both the ambitious amateur and the professional who aims at finer results than those given by the general run of printing papers.



THE DRIVING WIND
BY PAUL L. ANDERSON
From a Gum-platinum Print

CHAPTER XIII

TECHNIQUE OF GUM

THEORY.—The theory of gum printing is the same as that of carbon in so far as it depends on the insolubilization of a bichromate-sensitized, pigmented colloid film by the action of light, but varies from it in one important respect. In both cases the image consists of varying thicknesses of pigment-bearing colloid, but in gum work the variations of thickness are due to the fact that the paper support is rough, so that, if the film has approximately a uniform surface, the insoluble colloid extends varying distances down the sides of the little projections on the surface of the paper, the varying thickness of the film resulting from this irregularity in the surface. An interesting consequence follows from this, namely, that if a smooth gum coating is spread on a perfectly smooth surface, such as glass, no half-tones can be obtained on printing, a silhouette resulting, but if the gum coating is stippled a print with half-tones may be made, though the scale will be limited. It follows, also, that a rough paper will give a longer scale of gradation than a smooth, this fact being of importance to the gum printer.

In practice gum differs from carbon in that the colloid used is gum arabic instead of gelatine, that cold water instead of hot is (normally) used for development, that development takes place not from the back of the film but from the front, the soluble colloid seeping out through the pores of the overlying insoluble layer,

and that the paper cannot be bought ready prepared, but must be coated by the user.

Materials Required.—The materials necessary for gum work are paper, gum arabic, a bichromate salt, pigment, and two brushes, one for spreading and one for blending. These will be considered in the order given.

Many different papers are available, the two requisites being that the stock shall be such as to stand prolonged soaking in water, and that it shall be fairly well sized. Any good drawing or charcoal paper, such as Strathmore, Lalanne, or Whatman, may be used, but some will need resizing if multiple prints are to be made.

It is best to procure the highest grade of gum arabic and to obtain it in the form of lumps rather than powdered. It is most convenient to make up a stock solution of the gum as follows: Procure a large-mouthed bottle and tie two thicknesses of cheese-cloth over the top, so that the cloth hangs down in the form of a bag. Into this bag put 2200 grains of gum arabic and pour through it 12 ounces of water in which have been dissolved 30 grains of mercuric chloride. See that the gum hangs below the surface of the water, and allow it to stand, occasionally stirring the gum, until solution has taken place, two or three days being required. The function of the mercuric chloride is to act as a preservative, for, although a sour gum solution works quite as well as a fresh, it works differently, and will not be dependable for constant results. This gum solution will keep for months.

The sensitizer may be the bichromate of either

potassium, ammonium, or sodium, the first being usually recommended. The writer prefers the last-named, since it may be made up in a much more concentrated solution, giving a quicker printing film. The cost per pound of the salt is practically the same. If the potassium salt is used the sensitizer is

Water, hot	30 ounces
Potassium bichromate	1440 grains

If sodium bichromate is used the formula is

Water, hot	32 ounces
Sodium bichromate	2 pounds

The sensitizer keeps indefinitely.

The pigments may either be dry powders or in water-color tubes, the writer preferring the latter, since the dry powders require grinding, this being a laborious and dirty process. Oil colors cannot be used successfully. The water-colors may be those of any good maker, such as Talens & Son, Winsor & Newton, or Devoe, but it is best to adhere to those of one maker, since the different makes vary somewhat.

The fundamental color most used is black, and positive colors such as red, green, and blue are, generally speaking, to be avoided for esthetic reasons. It is, however, desirable at times to modify the black somewhat in order to obtain cold or warm blacks or browns, and the following pigments will be found useful:

Lamp Black, a strong color having a slight greenish tinge.

Ivory Black, a much weaker color, but pure.

Rembrandt Black, a strong pure color manufactured by Talens & Son.

Burnt Umber, a weak brown, very useful for modifying blacks.

Burnt Sienna, similar to Burnt Umber, but reddish in hue.

Prussian Blue, a strong, slightly greenish color.

Cobalt Blue, weaker than Prussian blue, but pure.

Cadmium Orange, a strong pure color.

Some workers advise other colors in addition to those enumerated, but the writer finds that the ones named will do practically everything that is desired except in very special circumstances.

The spreading brush should be of moderately stiff bristles, though if it is too stiff the paper may be injured. A good width of brush for any size of print up to $20'' \times 24''$ is three inches. The blending brush is the type known as a "flat badger blender," and should preferably be about four inches wide, since a smaller one will not work satisfactorily with large prints. After some skill has been acquired it will be found possible to blend perfectly on rough papers with the spreader, but the blender is always useful. The use of these brushes is not, however, imperative, since practice will enable the worker to spread and blend with any kind of brush that is not too stiff.

Sizing.—With good drawing papers it will not be necessary to size even if multiple prints are to be made, but some stocks are so porous that unless sized they will absorb the pigment unduly. The size may be either temporary or permanent, the former being the easier to apply if only single prints are to be made, but it possesses the disadvantage that it must be applied before each coating of the paper, thus introducing additional operations, whereas if the paper is permanently sized one application is sufficient, no matter how many

printings are given. The temporary sizing consists of a moderately thick boiled starch paste which is applied to the paper by means of a damp sponge and well rubbed in. For permanent sizing the formula is the same as that given in the preceding chapter for carbon transfer paper, one application, or at most two, being sufficient to produce the desired result.

THE COATING MIXTURE.—The coating mixture consists of gum solution, sensitizer and pigment, and is capable of infinite variations, though a few general rules may be given:

1. Increasing the proportion of gum increases contrast.

2. Increasing the amount of size in the paper increases contrast.

3. Increasing the proportion of pigment decreases contrast and gives a longer scale of gradation.

4. Excess of pigment will stain the paper and produce degraded lights.

5. Increasing the proportion of sensitizer renders the mixture easier to spread and blend, but gives a thinner film.

For every paper and every pigment there is a certain relationship between the amount of gum and the amount of pigment which will give the longest scale of gradations without staining the paper. This relationship is of great importance and may be determined as follows. Take a definite amount of the pigment (say one inch squeezed from a water color tube) and to it add ½ dram of the gum solution. Dipping a fine brush into this mixture, which should have been thoroughly stirred, make a mark on a piece of the

paper under investigation. Opposite this mark write in pencil "1 inch to ½ dram"; add another ½ dram of the gum solution, stir thoroughly and make another mark labeling this "1 inch to 1 dram"; add another ½ dram of the gum and proceed in the same manner, continuing the additions of gum until the proportion of pigment to gum is about 1 inch to 2 ounces. It will be observed that no sensitizer is used in this test. Allow the gum to dry thoroughly on the paper and then float the latter, gum side down, for one hour in water at room temperature, without agitation. At the end of this time examine the paper and it will be found that some of the marks have disappeared entirely, some are faintly visible and others are very distinct; thus it may be found that the highest mark is opposite the pencil label "1 inch to 8 drams," then if the gum pigment mixture be made up in the proportions of 1 inch of pigment to 8 drams of gum the lights in the resulting print will be faintly degraded, the amount of degradation being probably so slight as to be immaterial in single printing, though it will of course become apparent if multiple prints are made, and in this case it will be necessary to take 8½ drams of gum to 1 inch of pigment if clear lights are desired. A note having been made of the proper proportion of gum to pigment necessary for obtaining clear lights in automatic development, a soft camel-hair or sable brush may be rubbed over the test paper, when it will be found that still others of the marks disappear, the highest remaining after this treatment being perhaps opposite the label "1 inch to 4½ drams." This indicates that if 5 drams of gum be used to 1 inch of pig-

ment, clear lights will be obtained by the use of a brush or atomizer on the print during development. This test must be made for each paper and each pigment to be used, since some papers stain more readily than others and some pigments have far greater tendency to stain than is the case with others. If two pigments are to be mixed the amount of gum to be used follows naturally from the above test, thus if we say that it is necessary to use 4 drams of gum per inch of Ivory Black and 6 drams per inch of Burnt Umber, then if 1 inch of Ivory Black and 1 inch of Burnt Umber are mixed in order to obtain a brown it will of course be necessary to use 10 drams of gum. In general the transparent pigments such as Burnt Umber and Burnt Sienna have a greater tendency to stain than the more opaque ones such as the blacks.

Inasmuch as the proportions of the coating mixture vary with the pigment used, with the paper on which the print is to be made, and with the result desired, every worker must determine for himself what mixture he will use in a given case, and although numerous formulæ could be given, to do so would occupy an excessive amount of space and would serve no useful purpose, since it is obviously impossible to cover all conditions. Therefore but one formula for the coating mixture will be given and the worker will be left to make his own application of the fundamental principles stated above. This formula the writer has found to work satisfactorily with Strathmore Detail paper:

Gum solution	6 drams
Sensitizer	11 drams
Rembrandt Black	1 inch
Burnt Umber	1 inch

This gives a good warm brown and does not stain the paper.

COATING THE PAPER.—The paper to be coated is pinned by the four corners to a smooth horizontal board, the pigment is put into a mortar or saucer and the gum solution added a little at a time, rubbing thoroughly with the pestle or with the spreading brush until the gum and pigment have been completely mixed. The sensitizer is then added and the whole thoroughly stirred. The bristle brush is dipped into the mixture and is brushed rapidly back and forth across the paper, which, as in the case of platinum sensitizing, should be rather larger than the print is to be. It will probably be found that the paper will stretch when the mixture is applied to it and the slack should be taken up by shifting the pins, glass push-pins being recommended, since they are easier to manipulate than the ordinary type. The mixture having been spread as evenly as possible with the coating brush, the blender is then taken up and the streaks left in coating are smoothed out with it. Experience only can indicate the amount of mixture to be applied to the paper, for if too little is put on it will be impossible to cover the paper completely, whereas if too much is applied the film will be so thick that it will flake in developing. The rougher the paper the more of the coating mixture it will take, but no definite indication can be given. The use of the blender requires considerable manipulative skill, which also can be obtained only through experience. The blender should be held as nearly vertical as possible and should not press heavily on the paper, only the tips of the hairs touch-

ing, and should be moved rapidly up and down and crosswise of the sheet until the coating is uniform and for a little time thereafter. If blending is stopped too soon the mixture will run together in little puddles and will give spotty prints, whereas if it is continued too long, that is after the mixture grows tacky, the hairs of the brush will cause streaks which may show in the finished print. A slight streakiness will disappear during the operations of drying the coated paper and developing the print, and it is sometimes possible to remove brush marks by stippling the print all over with the blender, though this gives an entirely different texture in the final result. Generally speaking, blending should not occupy more than about thirty seconds, though with rough paper it may take longer.

The operations of preparing and applying the coating mixture may be carried out in an ordinary room since, as in the case of carbon, the paper is not sensitive until dry, but drying should take place in the dark and in ordinary circumstances will not occupy over an hour. If several sheets of paper have been coated the blender will be clogged with the mixture and will refuse to work properly, when it may be cleaned by rinsing under the faucet and spinning the handle between the hands.

If the gum-pigment mixture is too thick it will set before it can be blended satisfactorily, whereas if it is too thin it will take an excessively long time to blend.

Some papers, especially thin ones, buckle so when wet that it will be impossible to blend the mixture properly. If this is found to be the case the trouble may be avoided by soaking the paper until it is limp,

surface-drying between blotters and coating while it is still damp. However, if this is done there will be a greater tendency for the pigment to stain the paper than if the latter is coated dry, and allowance must be made for this fact when preparing the coating mixture.

Printing.—It is quite as impossible to give definite rules for printing as it is to give definite rules for the coating mixture, since the printing speed of the paper depends on the proportion of gum and sensitizer, on the proportion and color of pigment, and of course on the quality of the light and of the negative. Obviously the greater the proportion of sensitizer and the less the proportion of pigment the more rapid the paper will be, but the color of the pigment also exerts a marked influence, pigments of non-actinic color of course printing more slowly than the blues and greens. Generally speaking, blue will print most rapidly, black next and then brown and red in the order given. With the coating mixture given above the printing time will be roughly that of platinum, provided the potassium bichromate sensitizer is employed, though if the sodium bichromate sensitizer is used the printing time will be about one-fourth of this. It is possible to make an actinometer which will enable the worker to print accurately, but the writer prefers to rely on experience and on the use of test slips, printing by time, since this is generally easier than the other method.

Development.—The print should be developed as soon as taken from the frame, for the continuing action of light is the same with gum as with carbon, and to effect this the print is slid into a tray of water at room temperature, allowed to remain until limp, the water

being changed two or three times if convenient, and is then turned face down, care being taken to see that no air-bubbles adhere to either the front or back, since if this occurs dark spots are likely to result in the finished picture. The proper way to avoid air-bubbles in turning the print face down is to lift it by both ends, bending it in the form of a "U" and to lower it gently until the middle touches the water. The ends can then be lowered gradually and any loose air-bubbles will run out from under the paper as this is brought down to the surface of the water. Development may be either automatic or forced, the former consisting simply in allowing the print to remain face down in the tray until all of the soluble gum has floated off, raising the temperature of the water if this proves necessary. The high-lights of the picture or the edges where the print is protected from light by the rebate of the printing frame should appear in ten minutes or less and development should be complete in from one-half to one hour. If less time than this is required for the picture to appear as it should when finished, the print is probably under-exposed and the gum and pigment will run in drying. If development requires more than one hour for completion over-exposure is indicated, and this may be treated either by allowing the print to remain in the water until it is fully developed, the writer having at times allowed prints to develop for forty-eight hours, or if the exposure has been too great for this by raising the temperature of the water and in extreme cases by adding a slight amount of alkali to the developing water, as indicated in the chapter on carbon printing. The completion of development may

be determined by raising the print from the tray and allowing the water to drain from one corner back into the tray—which should be porcelain or porcelain-lined —when a stream of pigment will be seen running into the tray if development is not complete. When all the soluble pigment has been washed off the water draining from the print will not be discolored, but development may safely be arrested slightly before this point is reached. That is, if only a comparatively slight discoloration of the water is observed there is no danger of the gum and pigment running provided the print is hung up to dry, which should nearly always be done. If the print is laid in a horizontal position a film of water will remain on it much longer than if it is vertical and this film will tend to soften the gum still further and to cause running. A very beautiful effect may be obtained in this manner if the running is but slight, though to secure this effect at its best the exposure must be absolutely correct and development must be arrested at precisely the proper time.

The gum adheres to the paper but slightly when water-soaked, and for this reason values may be lightened to almost an unlimited extent during development. To effect this lightening various methods may be employed, these being arranged below in the order of their vigor, the first producing the least effort. The print should have been soaked for at least ten minutes before starting forced development, and the effect is greater if soaking has been longer than this.

1. The print is supported at an angle on a sheet of glass and a stream of water is allowed to flow gently over it from a hose or graduate.

2. The sheet of glass carrying the print is set nearly vertical and the print is sprayed with cold water from an atomizer, the most desirable being the kind designed to spray heavy liquids, such as albolene. The effect of using the atomizer is more vigorous and more concentrated when the nozzle approaches close to the print, diminishing in power and spreading over a larger area as the nozzle recedes from the paper.

3. The print being nearly horizontal, a succession of drops of water is allowed to fall on it from a slight elevation, either from a hose or from a graduate.

4. The print is lightly brushed while under water with a soft camel-hair brush.

5. The camel-hair brush is used while the print is out of water.

6. The end of a hose which is attached to the faucet is pinched up and a fine stream of water is directed against the print, the latter being supported on a sheet of glass.

7. A stiff bristle brush is used on the film.

Whatever method is used the print should be rinsed in clean water before being hung up to dry.

It is difficult to apply any of these methods so as to produce a decided change in values without interfering with the photographic quality of the print by introducing brush marks or other indications of manipulation, and for this reason automatic development is advised whenever it will produce the desired result, since an evident mixture of mediums, that is, photography and hand-work, is a violation of unity and as such is to be condemned from an artistic point of view. To be sure, it

is possible to modify values, as has been said, to almost an unlimited extent, and some workers use the gum process with this end in view, producing effects which bear some resemblance to a charcoal sketch or a pastel drawing, but this practice cannot be too severely condemned on artistic grounds.

An interesting comparison is observable between different schools of gum workers, this comparison being especially noticeable as regards the French and the German schools, the former generally working with one gum coating and with moderate size negatives, and developing very largely by means of a brush, so that the result has much the character of a charcoal or chalk drawing. The Germans and Austrians, on the other hand, work in large sizes and develop automatically, giving several printings to a sheet of paper, the evident intention being to produce mural prints rather than portfolio pictures and to vie directly with oil painting in effect. American workers do comparatively little gum work, their use of the medium being chiefly for addition to platinum, and English workers tend more to moderate size negatives automatically developed.

Multiple Printing.—Gum being a short scale process, it is impossible to render satisfactorily in one printing a negative having a long range of tones, and if this type of negative is employed a curve plotted for the resultant gum print would have much the same appearance as the characteristic curve of the plate given in Chapter III, the shadows being flat and lacking in detail, the lights being blank and only the half-tones having the proper gradation. Also it is impossible—

or nearly so—to obtain in one printing of gum a rich black, but both of these objections may be overcome by multiple printing, for repeated additions of pigment to the shadows will give any desired depth of color, and it is possible to print in such a fashion as to render the entire scale of the negative satisfactorily.

If the paper is coated and printed deep enough to record the gradations in the lights of the negative, then is dried, coated again and printed more lightly, the half-tones will be recorded over the dark ground left by the half-tones and shadows of the first printing. A third printing lighter than either of the others will record the shadows of the negative and give the desired result. Some workers elect to print for the shadows first, then for the half-tones and finally for the lights, but the writer prefers to follow the order given above, since the other method results in the shadows of the first printing and the half-tones of the second being covered by a gradationless layer of pigment resulting from the over-printing of the thinner portions of the negative in the later coatings. Some method of registration must be used to insure that the outlines of successive printings coincide, and many have been suggested, some of them being as follows:

1. A mask is used as for multiple carbon printing.

2. The paper is cut slightly smaller than the negative and is laid on it in the printing frame, pencil marks being made at the ends and sides, these marks, which of course are on the back of the paper and on the face of the negative, being made to extend about one-half inch in from the edge of the paper and as much on the

face of the negative, the marks being brought into coincidence for successive printing. This method is particularly applicable to enlarged negatives, in which case the large negative may be made on a piece of bromide paper or a dry plate a size or two larger than the finished picture is to be, so that none of the picture will be lost through cutting the printing paper smaller than the negative.

3. The method which the writer ordinarily uses is to use a printing frame a size larger than the negative, to lay the back of the printing frame upside down on a table, to place the paper film side up on this, lay the negative face down on the paper, and at each corner of the negative make a diagonal pencil mark on the paper, this mark extending perhaps an inch beyond the negative. The glass of the printing frame is then laid on the negative and the frame itself is placed in position, after which the whole is turned over and the back is clamped in place.

4. A printing board is used instead of a frame, this board consisting of a drawing board over which one or two thicknesses of felt have been stretched, the felt being fastened by means of tacks in the edges of the board. The paper is laid face up on this and the negative is placed face down on the paper. Stout pins are then thrust into the board in contact with the edges of the negative and the whole is placed to print. For subsequent printings the pins are replaced in the original holes in the paper and the negative is slid into position. This gives accurate registration provided the paper has been soaked and allowed to dry before the first printing in order to shrink it, but it is obviously

inapplicable to paper negatives unless a piece of glass is laid over the negative, and cannot be satisfactorily used with glass negatives smaller than 11×14, the weight of smaller pieces of glass being insufficient to keep the paper flat.

Of course it is not necessary that successive printings be in the same color any more than is the case with carbon, but generally speaking the lighter colors should be put on first and the darker ones afterward, as in the reverse instance the effect is apt to be unpleasant. The writer prefers to make the original negative such that the entire scale of tones may be rendered by one printing of gum and to use successive printings solely to add richness and depth. The negative for this technique should be very soft and should be as thin as possible, having no suggestion of fog or heaviness, partly because any veiling of the shadows will make it difficult to judge the printing time and partly because it will be difficult to secure a bright print from a veiled plate. The extreme shadows of the negative should be almost clear glass, but the lower tones should have full detail and gradation. This type of negative will be secured by giving slight over-exposure and considerable under-development and will be of a sort that will give a bright clear print on platinum without exhausting more than about half the scale of the ordinary commercial paper. It may be remarked that the production of a negative precisely suited to gum printing is probably the most difficult technical feat in the realm of pictorial photography, with the exception of the production of a set of negatives suitable for three-color gum work.

The Actinometer.—It was said above that an actinometer may be made which will facilitate accuracy in multiple printing, and for the information of workers who may desire to make such an instrument instructions are here given, these being taken largely from the very complete and thorough work of Dr. Kösters, entitled "Der Gummidruck."

A sheet of tracing paper twelve inches long and

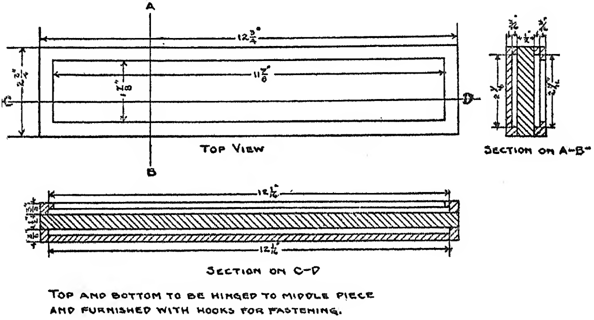


Fig. 43.

four inches wide is fastened over a clean piece of glass the same size by a touch of glue at each corner; another piece the same width but eleven and a half inches in length is fastened over this so as to leave one-half inch of the first uncovered; a third piece the same width and eleven inches long is then fastened over the second so as to leave one-half inch of this and one inch of the first without other covering. Successive pieces are then glued in place, each piece being one-half inch

shorter than the previous one, so that a photometer of twenty-four steps results. This is then cut in two so that two photometers each twelve inches long and two inches wide are obtained. These may be used either in ordinary printing frames or in special cases made for them as shown in Figure 43. The lower portion of this case serves to carry pieces of test paper.

It is not strictly necessary to determine the factor of this instrument, but it is convenient to have this information and it may be obtained in the following manner: Slips of P. O. P. are cut of the proper size and one is placed in the instrument and exposed to light for a definite period, say twenty seconds; the highest visible tint on this print is then noted (the different steps should of course be numbered in heavy figures, using black drawing ink) the piece is then replaced in the photometer and exposed to light for another definite period, say four hundred seconds. If now the time required for the P. O. P. to show a visible tint when exposed without the photometer is called "t" and the factor of the instrument is called "a" the time required for the paper to show a tint under the first step of the instrument will be $t \times a$ and the time required for it to show a tint under the second step will be $t \times a \times a = ta^2$, since each gradation of the photometer absorbs a certain percentage of the incident light. In like manner the time required for the next step to appear will be $t \times a \times a \times a$, that is, ta^3. Then the time required for step "m" to appear will be ta^m and for step "n" to appear will be ta^n. Calling the total time required for "m" to appear "x," and the

total time required for "n" to appear, "y", then we have

$$ta^m = x$$
$$ta^n = y$$
$$\frac{ta^n}{ta^m} = \frac{y}{x}$$
$$a^{n-m} = \frac{y}{x}$$
$$a = \sqrt[n-m]{\frac{y}{x}}$$

To take a concrete example, suppose tint 4 appears in twenty seconds and tint 8 appears in 5 minutes and 20 seconds, then we have

$$\frac{a^8}{a^4} = a^4 = \frac{320}{20} = 16$$

and a equals 2; that is, the factor of the instrument is 2, which means that each tint requires twice as long to appear as the preceding one, since each step of the paper absorbs half of the incident light. Paper which absorbs this much light would, however, give an unnecessarily extended scale of gradation and would be unsatisfactory, the most desirable factor being between 1.2 and 1.25. It should be noted that most samples of tracing paper will turn yellow with exposure to light and the factor will then increase so that the photometer must be renewed from time to time. It is convenient to determine the factor of each step of the instrument, which can of course be done by obtaining the successive powers of the fundamental factor. That is, if $a = 1.2$ this will be the factor for the first step, the factor for the second being $(1.2)^2$, that for step three being $(1.2)^3$, and so on. These powers are most readily obtained by the use of a table of logarithms,

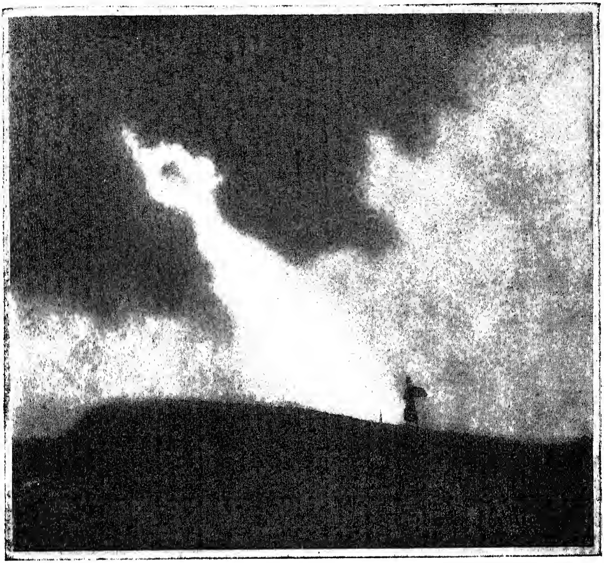
which is practically necessary in obtaining the fundamental factor of the instrument. This fundamental factor should naturally be the average of a half dozen or more readings, since possible errors are thus minimized.

The method of using this photometer is this: First the speed and scale of the coated paper are determined, and this is done by placing a strip of the paper to be used for printing in one of the photometers and a piece of P. O. P. in the other, both photometers being then exposed to light simultaneously for a definite length of time, say ten minutes, and when they are taken in the highest visible tint on the proof paper is noted. The strip of gum paper is then allowed to develop automatically for an hour in water in room temperature, when the highest and lowest tints visible are read. We will suppose that the highest visible tint on the P. O. P. is 12 and the highest visible on the gum paper is 14; this then means that to print to a certain depth on this gum paper we must always print two tints lighter on P. O. P. If the lowest tint which is not blocked up on the gum paper is 8, say, then it is apparent that this particular coating mixture will register 6 steps of the photometer. The quality of the negative is then determined by putting a sheet of P. O. P. into a printing frame with it and a piece of P. O. P. into one of the photometers. The negative and photometer are then put out to print and are printed simultaneously until the P. O. P. under the negative is printed proof deep, when they are taken in and the highest tint visible in the photometer is read. We will suppose this to be 10, and this determines at

once the intensity of the lights in the negative and probably the scale of gradation also. Then when we come to print in gum from this negative it is apparent that we shall wish to print to tint 10 of the gum paper and this is done by putting the paper under the negative and a strip of P. O. P. in the photometer to print simultaneously, the exposure being just long enough to render tint 8 visible on the test slip, for we found that the gum paper prints two tints more rapidly than the P. O. P.

If this method is followed practical certainty in printing results, although slight errors may be introduced owing to the difficulty of judging the highest visible tint in the photometer. Still, variations in the temperature of the developing water will take care of this error. It is apparent that if the scale of the negative is measured by 10 tints of the photometer, it will be necessary to give the paper two printings of this particular gum mixture, since we found that the coating in question registered 6 steps of the instrument. Should the density of the lights in the negative be represented by tint 15 of the photometer three printings would evidently be required. Obviously, in the first case the second print would be such as to register tint 4; that is, printing would be continued until tint 2 of the photometer becomes visible, and in the other case the second printing would be for tint 7 and the third for tint 1.

The relative sensitiveness of a bichromate-sensitized colloid film as compared to P. O. P. is greater in a weak light than in a strong one, so that if the determinations indicated above of the relative printing depths of



THE DRIVING WIND
BY PAUL L. ANDERSON
From an Oil Print

P. O. P. and of gum paper are made on a bright day during the hours when the light is strongest, it will be found that printing by this method will result in excessive exposure of the gum paper when the work is done early in the morning or late in the afternoon or on a dull day. This error may be avoided by using in the photometer freshly prepared strips of paper coated with a bichromate-sensitized gum film, this being made by coating a piece of paper with a standard mixture of gum solution and sensitizer, using no pigment at all, and this is dried in the dark, when it may be cut up into slips and used for test purposes. Evidently the relative sensitiveness of this test paper to strong and weak light will be the same or nearly the same as that of the printing paper, and the numbers of the actinometer may be read directly upon it, there being no pigment to mask the color of the bichromate image.

Some workers give ten or twelve printings and the writer has even heard of one who habitually gives from twenty-five to thirty, but any such number of printings is quite excessive, since a suitably adjusted coating mixture will give any richness of shadows which may be required in four printings and will render the gradations of practically any negative in from four to six.

Failures.—As has been said, gum is the most flexible of all printing mediums, and for this reason failures are more apt to occur than with any other. If, however, the worker has a good grasp of the principles of the process he will be able to determine for himself the cause of any particular defect, though a few of the commoner ones are noted here.

Over-printing and under-printing of course manifest

themselves by the print either requiring an undue length of time for development or developing too rapidly. If the trouble is over-printing the lights of the picture will remain dark, but the margins of the print which were protected by the rebate of the printing frame will develop clear. Should the margins fail to develop clear in half an hour, the trouble is due to an excess of pigment in the mixture, the paper being stained, to staleness of the paper, or to the fact of the paper having been exposed to light when not in the printing frame.

If the print flakes in development, that is, the gum peels off in patches instead of developing smoothly, the trouble is due to one of five causes: 1. Excess of pigment in the coating mixture, this indicating itself of course by stained lights. 2. The application of too thick a coating of the mixture to the paper. Only experience can determine the proper thickness of the coating, but it may be said that the prepared paper should not in general appear black but rather of a medium or dark gray, the coating being thin enough to allow the paper to be seen slightly through it. 3. Excess of gum in the coating mixture. This will show itself at the time of coating the paper, since too thick a mixture will be difficult to spread and will become tacky so rapidly that it will be difficult, if not impossible, to blend it properly. 4. Too much alkali in the developing water. 5. Excessive amount of size in the paper. If this last-named fault is the cause of the trouble it can be determined only by the fact that it is not due to any of the other causes given.

If the print shows a streaky texture this may be

due either to faulty blending or to removing the print from the developing tray too soon and hanging it up to dry. In the former case the streaks will be comparatively fine and may be in any direction, either vertical, horizontal or oblique. In the latter case they will be broader in character and their direction will of course depend on the position assumed by the print in drying. Streaks caused by faulty blending will be apparent on the paper before it is printed.

A general running of the image is due to under-printing or to insufficient development. Under-printing will of course show itself in the developing tray.

Staleness of the paper will manifest itself by a refusal to develop and is difficult to distinguish from the effect of excessive pigment in the mixture when the excess is not sufficient to cause flaking. Gum paper deteriorates very rapidly and should be kept in a sealed platinum tin with preservative unless it is to be used immediately after drying. Even if kept in this manner it does not remain in first-class condition for more than a day and may become entirely useless in two or three days, owing to the insolubilization of the gum which takes place even without exposure to light.

CHAPTER XIV

TECHNIQUE OF GUM-PLATINUM

THE reasons for adding a printing of gum to a platinum print have already been given, and little can be said concerning the technique of the process, since this is covered under the headings of platinum and gum, the process consisting simply of making a platinum print and using that as a paper on which to make one or more gum prints.

It will be found convenient to make the platinum print on a sheet of paper somewhat larger than the negative, since this facilitates the application of the gum coating. This, however, is not strictly necessary, for by careful working it is possible to coat up to the very edges of the print.

In practically all cases it will be found desirable to size the platinum print before applying the gum, and this may conveniently be done with a boiled starch paste as indicated in the chapter on gum printing, this being easier to prepare than the gelatine size and being usually sufficient, since it rarely happens that more than one printing of gum will be given. The necessity for sizing is due to the fact that the various chemical baths which the platinum print goes through have a strong tendency to remove the size from the paper.

The gum mixture should ordinarily be rather weaker in pigment than for straight gum printing, since the platinum print itself furnishes fairly rich blacks and

the purpose of the gum is to add somewhat to their value.

It is not necessary to adopt any special methods of registration in gum-platinum work, this being very easily effected by placing the print on the negative in a printing frame, holding it up to a concentrated light, such as a Welsbach light, in a relatively dark room and shifting the print about with the fingers until it is seen to be registered, when the frame is carefully lowered to the table and the back clamped in, the print being held in position on the negative while clamping the first section of the back in place. If a printing frame the size of the negative is used it will be found desirable to trim the print about one-sixteenth inch smaller all around than the negative before attempting to register. The fact that this method is possible in gum-platinum but not in gum is due to the much greater opacity of the platinum image as compared to that of the gum. If two or three printings have been given to a gum print it may then be registered by this method if desired, and in any case it will be easier to register the print if the negative is toward the worker than if it is between the print and the light.

Development of a gum-platinum print should in general be largely automatic, since brush work is more noticeable in this case than in straight gum printing, owing to the much more definitely photographic character of the platinum image. It is, however, possible to intensify the lights to a certain extent without the effect being conspicuous.

Gum-platinum is useful in many ways, such as for the purpose of obscuring shadow detail which is not

desired or for adding color to the print, but in the writer's opinion its chief value is found in portraiture. Yellow and red, which characterize the major portions of the face, are colors which have strong psychic value; that is, they are unconsciously associated in our minds with light and warmth and hence appear much stronger than their true photometric value; also, in conversing with an individual or in looking at one at a short distance, the attention as a rule is concentrated on the face, so that the clothing appears to us rather indeterminate, except in the case of a noticeably dressed woman. For this reason our ordinary impression of a Caucasian is of a light area surmounting a darker or less defined area representing the clothing. Careful analysis shows that the skin is in reality much darker than white linen and many photographers attempt to render this relationship rather than the true psychic relationship by making the face considerably darker than the collar or other white portions of the cloth, so that they represent accurately a minor truth—the values of the linen—at the expense of a greater one. On the other hand, if the photographer desires to give the true impression he usually endeavors to accomplish this through either under-exposure or over-development of the negative, the former obliterating shadow detail by failure to render it on the plate, the second obliterating it by necessitating over-printing of the shadows in order to record the gradations in the lights. Either of these methods gives a scale of tones which is quite as false as that resulting from the technique first mentioned, since both methods extend the scale of tones in the face unduly.

The desired effect may readily be obtained without falsifying the values in the face by making a normal negative, erring on the side of under-development rather than over-, and making from this negative a gum-platinum print, for the platinum will render the scale of the face as it should be rendered and the additional printing of gum will, if properly adjusted, subdue the shadow detail without extending unduly the gradation in the features. In addition, the increased weight given to the shadows by the gum printing without a corresponding increase of weight in the lights will tend to emphasize the latter by means of contrast, and the writer finds that a portrait handled in this manner, especially if it be of a strong-featured man, is exceedingly effective. For children and for women in light clothes it is not so much to be recommended, though a soft negative printed in gum-platinum will in the case of a satin gown give a quality of texture to the cloth which the writer has never seen equalled in any other printing medium except oil.

It is much easier to make a gum-platinum print than to make a gum print, since in the first case it is simply a question of adding a certain amount of weight to an already nearly completed print, and the worker is not as a rule obliged to consider the question of rendering the gradations of the negative with the same care as is necessary in gum printing. It will, however, be found much easier to make a gum-platinum if the platinum print was normally exposed so that the lights are rendered satisfactorily and weight is added merely to the half-tones and shadows than if the platinum print was under-exposed and an attempt is

made to add by means of the gum gradation which is lacking in the lights. This is due to the fact that in many circumstances the gum process has a tendency to flatten the lights, this resulting from the transparence of the pigment in the upper register unless enough is added to cause flaking in the shadows. Also it will be found that gum-platinum presents a considerable economy of time and effort over multiple gum, for the reason that platinum paper will render shadows as dark and a scale of gradation as full as can be obtained in two or three printings of gum, so that the original platinum print represents in its values the equivalent of perhaps three gum printings, and is made with much less effort. Further, unless extreme care is taken in registering successive printings it will be found that each additional printing of gum tends to add a looseness to the outlines of the image, even though the registration is not so bad as to give definite double outlines, for which reason gum-platinum tends to preserve the accuracy of drawing of the negative with greater precision than is the case with multiple gum, though the shrinking of the platinum print will often make precise registration impossible. In such a case the most important parts should be registered, and the faulty outlines may often be remedied by a few touches of a pencil on the finished print.

CHAPTER XV

TECHNIQUE OF OIL AND BROMOIL AND OF TRANSFERRING

Theory of Oil.—Oil printing is practically identical with the reproductive process known as collotype except that the support is paper instead of glass and that a brush is generally used for applying the ink, though in some cases a roller is used for this purpose as in collotype work. If a film of unhardened gelatine is spread uniformly on a sheet of paper and when dry is sensitized with a solution of a bichromate salt, this gelatine film will on exposure to light under the negative be tanned in proportion to the amount of light action; that is, the shadows, which have received the most light, will be strongly tanned, the half-tones less so and the lights least of all. If the sensitizer is then washed out of the film and the print is soaked for a few minutes in warm water, the less tanned portions absorb water more freely than those which have received greater light action and acquire the property of repelling an oily ink, the degree of repulsion of the ink depending on the amount of water in the film.

Theory of Bromoil.—In the case of bromoil the print is made either by contact printing or by enlargement on a sheet of bromide paper which is developed, fixed, and washed in the usual manner. This print is then treated with a solution of certain chemicals, the effect being to tan the gelatine in proportion to the amount of silver contained in the film. Hence the shadows are most tanned, the half-tones less and the

lights least of all. Washing and soaking results in the gradations of the print assuming in varying degrees the power of repelling a greasy ink exactly as is the case in oil printing.

THEORY OF TRANSFERRING.—The oil or bromoil print is prepared and inked in the usual manner, using a somewhat softer ink than is generally employed. This print is then placed in contact with a sheet of paper, which should not be too heavily sized, and the two are run through a roller press, such as an etching press or a clothes wringer. The result is that most if not all of the ink from the image in the oil or bromoil print is transferred to the uncoated paper and the final result somewhat resembles a lithograph.

MATERIALS REQUIRED.—The paper should, as has been said, be coated with a film of unhardened gelatine, and commercial oil papers are obtainable, but the writer finds that the most satisfactory oil paper with which he is acquainted is made by taking a good bromide paper which has not been hardened in manufacture, fixing it without exposure to light in a 20 per cent. plain hypo bath, washing for one hour in running water and drying. The paper thus prepared will keep almost indefinitely, a small amount being sensitized as required. Generally speaking the smooth grade is to be preferred, though in some cases the rough may be desirable.

The sensitizer is a solution of potassium, sodium or ammonium bichromate, and the most generally useful strength is a 2½ per cent. solution; that is, 480 grains of the salt dissolved in 40 ounces of water, though for some purposes the bath may be used stronger or weaker than this.

A half dozen lintless blotters a size larger than the paper to be printed are necessary, as well as several soft lintless cloths, well-washed linen or cotton handkerchiefs being the most desirable which the writer knows.

Inks will be required, and these may be either the specially prepared inks furnished by the manufacturers of oil printing supplies or stiff lithographic inks, the latter being obtained from any dealer in printers' inks and being preferably packed in collapsible metal tubes. These inks may be obtained in tubes of varying size and when purchased in quarter-pound tubes are not only quite as satisfactory as the specially prepared inks but cost something like one-tenth as much as the latter. Brushes will be needed, and these are of a special type, being known when prepared for oil printing as "stag foot oil printing brushes" and when purchased of a dealer in painters' supplies as "fitch stipplers, cut slanting." The French and English oil brushes cost about twice as much as the American made fitch stipplers and are worth the difference. It will be found desirable to have at least three brushes, one about one-eighth or one-fourth inch diameter for fine work and two about one inch diameter or larger for general use. If prints larger than 11×14 inches are to be made it will, however, be found desirable to have the larger brushes of the largest size which can be obtained, since the use of a small brush on large prints prolongs unduly the time required for inking.

Either gasoline or soap and water may be used for cleaning the brushes, and this should be done immediately on the completion of inking, since if the ink

is allowed to dry on the brushes it will be difficult to remove. The brushes when not in use should be kept in paper cones to preserve their shape. A sheet of glass about 8×10 inches or a china palette will be required, and it is convenient to have a palette knife, although this is not strictly necessary. Some medium for thinning the ink will be required at times and this may be either boiled linseed oil, turpentine, megilp or Roberson's or Sinclair's medium. A very small amount is sufficient and an ounce of any of these will probably last the ordinary worker many years.

It is convenient though not imperative to have a board on which to place the print for inking and this may conveniently be made as follows: An ordinary draftsman's drawing board of suitable size is either given three coats of spar varnish or is covered with oilcloth drawn smoothly over the surface and tacked firmly along the edges. A piece of well-washed muslin slightly larger than the board is tacked to one end of the latter so that six or eight wet blotters may be laid on the oilcloth and the muslin drawn over them, being fastened in place with push-pins.

Sensitizing.—As stated above, the best strength of sensitizer for general use is a 2½ per cent. solution, though it may be used as weak as 1 per cent. if more contrast is desired or as strong as 5 per cent. if softer prints are wanted. Weakening the sensitizer does not interfere with precision in exposure, as is the case in carbon printing, since the image prints out to a certain extent and the time of printing is gauged by the appearance of the paper in the frame. The method of use is the same as in the case of carbon; that is, the

paper is immersed for two and one-half minutes and is then squeegeed face down on a clean piece of glass to remove the excess of sensitizer and is hung up to dry in the dark. The use of the ferrotype plate presents no advantage in oil printing and retards drying somewhat, since only one surface of the paper is exposed to the air. As with carbon and gum, sensitizing may be done in an ordinary room, but drying must take place in the dark, oil paper when dry being much more sensitive to light than carbon. A sensitized oil paper deteriorates more rapidly than carbon tissue, and is at its best immediately after drying, though if carefully kept it may remain in fair working condition for a few days. A quick-drying sensitizer may be used, and many workers, including the writer, prefer this both because of its greater flexibility and because of the rapid deterioration of sensitized tissue, the spirit sensitizer making it possible to sensitize and print on the same day. A good formula follows:

Stock solution.	
Water	4 ounces
Sodium bichromate	4 ounces
For use take	
Stock solution	1 to 8 drams
Alcohol, 95 per cent. to make total volume	2 ounces

This is spread evenly over the paper with a Blanchard brush or a flat Japanese paint brush, and if a standard amount is used for a given size of sheet the results will be uniform. This sensitizer dries so rapidly that it should be applied by artificial light or in weak daylight. The paper will dry in from five minutes to half an hour, depending on the proportion of alcohol and on the atmospheric conditions, the stronger sensitizer being of course used for soft results.

Printing.—The best type of negative for oil printing, that is, one which will exhaust the possibilities of the process, is one which, although by no means harsh, should nevertheless have more contrast than for gum work. It will give a moderately bright print in platinum, though it will by no means exhaust the scale of platinum paper, and since the oil process tends to soften outlines somewhat these should have in the negative rather more firmness of drawing than for an equivalent amount of diffusion in platinum or carbon.

Printing is done by sunlight or strong artificial light and should be continued until the highest lights of the picture have a slight tone, unless, as is sometimes the case, a pure white is desired in the lights, the appearance of the print in the frame being very similar to that of a piece of platinum paper in the same circumstances. When exposure is complete the print should at once be washed in water at about room temperature until all the free sensitizer has been removed. It will not be possible to wash out all traces of the image, since a certain amount of tone will always remain in the shadows. Washing should not be delayed, for the continuing action of light is the same with oil as with carbon and gum. After the print is thoroughly washed it may either be soaked and inked at once or may be hung up to dry and kept for an indefinite period, any further change in the gelatine film taking place with extreme slowness. The writer has known of prints which had been thoroughly washed being inked satisfactorily six months after printing, but the film will in time deteriorate and the ink will not take properly.

It is necessary to employ a safe-edge and this should

be rather wider than for the carbon process, half an inch being none too much, since the purpose of the safe-edge is to keep the inking brush from touching the wet pad on which the print must rest during inking, for if the brush takes up any water it will not deposit the ink properly. The safe-edge also furnishes a convenient indication of the correctness of both exposure and soaking, since if the print is properly handled the margin will remain clear both in the printing frame and in the inking. Very pleasing effects may be obtained by using paper a size larger than the negative, *i. e.*, 11×14 for an 8×10 plate, printing with a mask in the frame, and leaving the entire margin to serve as a border. If the ink takes on the edge it may be removed before hanging the print up to dry, by wiping with a damp cloth wrapped about the finger.

Soaking.—After washing the print must be soaked for a few minutes in warm water and no definite instructions can be given for this part of the process, the degree of soaking varying with circumstances. If the print has been over-exposed, warmer water will be needed for soaking than if printing has been normal, increase of temperature in the soaking water causing the film to absorb a greater amount of water than would otherwise be the case, thus giving it a greater repellent effect on the ink. It will be apparent from this that the use of warmer water not only means a higher value in the lights but also gives the print greater contrast, since the lights are more affected than the half tones and these in turn more than the shadows. If it is found on inking that the print has been soaked in water at too high a temperature, which is indicated by

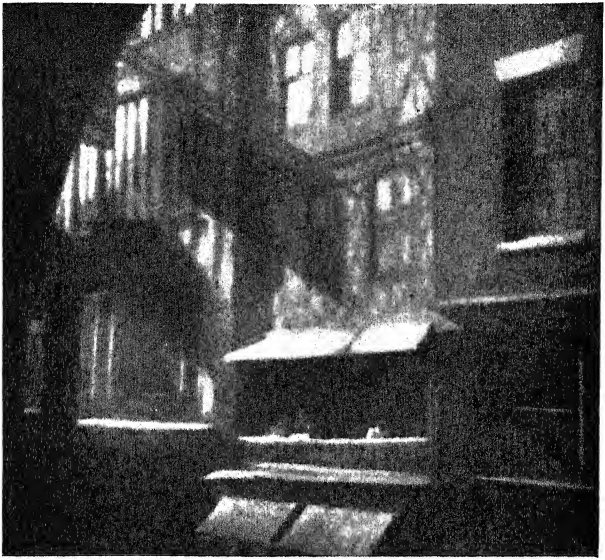
the lights refusing to take the ink properly, it may be allowed to dry out partially. About the only guide which can be given in the matter of soaking is to say that a normally exposed print should be soaked in water at such a temperature that the gelatine film on the unexposed margins which were protected by the safe-edge should, on rubbing between the thumb and finger, rub off with moderate ease, though this applies especially to the commercial oil papers, such a marked softening being unnecessary with the bromide paper. If any doubt is felt as to the sufficiency of the soaking, a corner of the print may be surface-dried and the ink tried on the dry area. If the ink takes on the print but fails to adhere to the safe-edge the soaking is probably correct.

Generally speaking, the soaking should end in water at about 110° Fahrenheit, and better results will be obtained if the soaking is begun in water at about 95° Fahrenheit, the temperature of the water being gradually raised to the proper point, than if the print is placed at once into the warmer water. In case of serious over-printing the water may be used much hotter than this, though excessive heat will probably cause the gelatine of the safe-edge to tear during the inking. When the print has been sufficiently soaked, which will probably require about ten or fifteen minutes, it is lifted from the tray, drained, and placed face up on a sheet of glass or other smooth surface. It is then dabbed lightly with a wad of lintless absorbent cloth until surface-dry, when it is laid on a pile of half a dozen wet blotters or on the inking board described above, and inking may be begun.

Inking.—The final result depends in great measure on the character of the ink and the method of its application, and experience is the only satisfactory guide in these matters. A small quantity of the ink is squeezed from the tube on a clean piece of glass or a china palette and is spread out in a film about one-sixteenth inch thick by means of the palette knife. A quantity of ink the size of a large pea will serve to ink three or four 8×10 prints. One of the large brushes—which are cut to a slant, the ends of the hairs being slightly domed—is dabbed lightly in the ink and is then dabbed two or three times on a clean portion of the palette in order to distribute the ink among the hairs. The brush is then pressed with only moderate force on the print, when it will be found to leave some of the ink on the film. After two or three touches of the brush on the print it must be dabbed in the ink again and the ink distributed as before, the operation being repeated until the print is satisfactorily inked. It will be found advantageous when dabbing the brush on the palette to distribute the ink to dab always in approximately the same part of the palette, since an exceedingly thin film of ink is thus deposited on the palette and the brush will work better than if a fresh spot is chosen each time. Some workers advise inking either the high lights or the shadows up to their proper value at first and then proceeding to the rest of the print, but the writer prefers to ink lightly over the entire area of the print at first, gradually building up to the desired degree of contrast, the effect being thus more directly under the control of the worker. The appearance of the print will probably be very discouraging at

first, but inking should be continued and the image will gradually attain its proper character if the preceding operations have been correctly carried out.

There are two methods of handling the brush, and these produce widely differing results. A slow pressure of the brush on the print deposits ink on the film, whereas a quick "hopping" action removes ink already adhering, this effect being especially noticeable when a clean brush is used. If it is found difficult to deposit sufficient ink to obtain the desired depth in the shadows the ink may be thinned with any of the mediums mentioned above, the least desirable of them being turpentine, and there being practically no choice among the others. The ink will probably be sufficiently thinned if a single drop of the medium is placed on a clean piece of glass and the palette knife is lightly dipped in this drop, the small quantity adhering being then mixed with the ink. The possibilities of increasing the contrast in this manner are unlimited, since if the ink is sufficiently thinned it is possible to produce an absolute black even on the safe-edge, and a great deal may be done to lighten the values by hopping, this hopping action being easier to effect when only a slight amount of ink has been deposited on the print. It is difficult to describe precisely the method of hopping, but it consists essentially in allowing the brush to strike the film with moderate vigor and removing it suddenly from contact. Some writers say that hopping is done by allowing the brush to fall on the print and catching it on the rebound, but the writer prefers to throw it lightly against the film and then catch it as it leaves the print.



A SIGN SHADOW, CHESTER
BY CHARLES KENDALL
From a Bromoil Transfer

It will be seen that unlimited possibilities of control of relative values and of total contrast inhere in the process, since it is possible to deposit as much or as little ink on a given area as may be desired, even leaving it off entirely, and it is also possible to remove much of the ink which has already been deposited. Some writers advocate inking the print at once for a normal result, afterward lightening portions by hopping, but the writer prefers to work with a guide print, for example, a P. O. P. proof, before him and to deposit ink only where it is needed for the desired pictorial effect, since it is not possible to remove an indefinite amount by hopping. Brush-holders for hopping may be obtained, these consisting of a piece of spring wire several inches long, having at one end a handle and at the other a device for holding the brush. The writer has found that the use of such a holder is very likely to result in tearing of the gelatine film.

The texture of an oil print is practically always slightly grainy, since each individual hair of the brush deposits a small spot of ink, the image being built up by repeated applications. There is, however, a great difference in the textures obtainable, for if a stiff ink is used and the entire surface of the print is worked over for a long time these minute spots of ink are spread by repeated touches of the brush and the final result will have a fine texture. If, on the other hand, a relatively thin ink is used, so that the desired gradations are rapidly built up, the texture will be coarse. An 8×10 print may be inked up to full contrast in ten minutes with a thin ink, when the texture

will be decidedly coarse. If the stiffest possible ink is used with a view to obtaining a fine texture a print of this size may require an hour or more for complete inking.

Although it is possible to apply a thin ink over a stiff one, it will be found that a stiff ink will refuse to adhere over a thin one unless the latter has first been dried.

It is possible to ink a print to a certain depth and then dry, resoaking and completing the inking at a later date, but the writer prefers to finish a print at one sitting, for he feels that by this method the best results are obtained, the effect being not only better technically but being also freer and more spontaneous from an artistic point of view. If the print has been dried and resoaked, it will be possible to apply ink by dabbing, but hopping will not remove any of the first application.

A new brush will probably shed hairs in great profusion on the print, these being either pulled out of the brush or broken off. It is well to remove each hair as soon as it is observed, by lifting it on the point of a needle or knife, which may very readily be done without injury to the print. If the hairs are allowed to accumulate on the print they will leave marks when working over them and these marks will have to be spotted out in the finished print. After two or three prints have been inked, the brush will probably cease to shed hairs, or at all events will lose one but rarely.

Drying and Degreasing.—When the print is satisfactorily inked it should be set to dry and should be pinned up by the four corners in a vertical position,

since if it is laid horizontally dust will settle on it and if the corners are not firmly held it may curl up and crack when straightened. Drying will take from two hours to two weeks, depending on the stiffness of the ink and on the amount applied. When the print is dry it may be worked on freely with a pencil eraser to lighten values or ink may be applied to a given area with the brush, though it must be remembered that ink will adhere to the dry print much more freely than when it is wet and that it will adhere uniformly over the entire surface.

The finished oil print has always a certain lustre, this being due to the medium in which the pigment is ground. Should this lustre not be desired it may be removed by soaking the print for about fifteen minutes in gasoline, and this soaking should take place as soon as the ink has become thoroughly dried and not until then, for if it is done too soon the pigment will be removed from the paper and if it is left too long the oily medium will not be dissolved from the ink.

General Remarks.—Any one who has followed the foregoing description with care will be able to induce for himself the cause of any particular failure, but a few general indications may be given.

Over-printing or insufficient soaking will give too dark a print, but these faults are readily differentiated, since with over-printing and proper soaking the print will have the proper degree of contrast and the margins will remain clear, whereas with correct exposure and insufficient soaking the print will be flat and lacking in contrast and the margins will take the ink.

The effect of under-printing is, of course, obvious,

and excessive soaking may cause the gelatine of the safe-edge to tear under the brush and will cause the high lights of the picture to refuse to take ink. In extreme cases over-soaking will cause tearing of the film in the lights.

Too stiff an ink will refuse to adhere to the lights and too thin an ink will adhere too readily, the former defect being seldom found. As a corollary to this it may be noted that a stiff ink gives contrast, whereas a thin ink gives flatness.

Should the print be thickly covered with fine black specks, this is probably due to an excessive amount of ink on the brush, and the latter may be cleaned sufficiently to permit of continued use by rubbing on a clean cloth or piece of blotting paper. Should the print show a number of small white spots, these are probably due to the brush having become wet through touching the blotting papers, and if it cannot be sufficiently cleaned on a dry cloth it must be washed out and allowed to dry for several hours.

The brushes should be cleaned immediately after use, and if gasoline is used the brushes will probably be dry enough to use in an hour or two, but if they are cleaned with soap and water they will take three or four times as long to dry. They should be dried in the paper cones in which they are kept, or the hairs may spread and the brush soon become useless.

It will be found that fixed-out bromide paper has a much thicker coating of gelatine than the commercial oil paper, for which reason it permits the use of stronger negatives. It should be noted that if a hypo bath containing alum is used for fixing the paper will prob-

ably be useless for oil printing, since this process depends on the fact of the gelatine not having been tanned.

Should it be found that the inking is not proceeding satisfactorily, the print may be cleaned with gasoline, dried and resoaked.

Bromoil—The Negative.—A negative suitable for use with the bromoil process will be in general much softer than one suitable for oil printing, though this depends somewhat on the paper used.

The Bromide Print.—For developing the bromide print it is best to use a developer which has no tendency to tan the gelatine; that is, amidol or dianol, since these work without the use of an alkali, although such a developer is by no means imperative. The print should be thoroughly developed so that all the light-affected silver is reduced to the metallic state, and in order to secure this condition development should be continued for two or three minutes after the print has ceased to gain strength. Fixation should take place in a plain hypo bath, for if a hardening bath is used it will be almost impossible to swell the gelatine sufficiently to permit of inking. The writer has inked a print which had been fixed in a hardening hypo bath by giving it a prolonged immersion in an acid solution and soaking in water at about 150° Fahrenheit, but this technique is not recommended.

The bromide print should be by no means a strong one, for if the shadows approach the full depth possible to the bromide process it will be difficult to obtain complete rendering of the shadow detail in inking. It should be borne in mind that softness in the bromide

print will not interfere with the obtaining of a full rich black in the finished print, since ink may be added to practically an unlimited extent.

Bleaching.—The purpose of the bleaching solution is to tan the gelatine by reaction between the bleacher and the silver image, and there are formulæ almost innumerable for this purpose, different workers having their especial favorites. The writer has found the following two formulæ to be thoroughly satisfactory:

Water	14 ounces
Copper sulphate crystals	260 grains
Potassium bromide	260 grains
Potassium bichromate	48 grains
Hydrochloric acid C. P.	30 minims

Water	24 ounces
Copper sulphate crystals	130 grains
Sodium chloride	720 grains
Potassium bichromate	10 to 50 grains

Increasing the amount of potassium bichromate increases the tanning action, and the worker should experiment for himself with the paper he wishes to use, since different papers require different treatments. If the bleacher is used warm (up to 100° Fahrenheit) greater relief is obtained, and this is sometimes necessary in the case of a hard gelatine. A gelatine which is so hard as not to respond to the use of a warm bleacher and hot water for soaking may often be improved by soaking for a few minutes in a 3 per cent. solution of sulphuric acid C. P., which also may be used warm. The acid bath, however, will rarely be necessary if the print is of the proper quality and has been fixed in plain hypo. The bleacher given above keeps well and may be used repeatedly, but it is

generally preferable to make it up fresh for each batch of prints, since more uniform results are thus obtained. The fixed and washed print is immersed in the bleacher until no further action is observed, although the image will not be entirely removed. It is then washed in running water until free from bleacher, when it may either be inked or may be dried and reserved for future inking. Drying is not imperative, but better results are obtained if it is done, since the full tanning action of the bleacher is not secured otherwise. Of course, a number of prints may be bleached at a time and kept, but it is not advisable to postpone inking for more than a few weeks at most, though bleached prints have been successfully inked six months after treatment. It is well to fix the print in a plain hypo bath after bleaching.

Subsequent Treatment.—The subsequent technique of the printing, that is, the operations of soaking, inking, drying and degreasing, is identical with that used in the case of oil printing.

Transferring.—Transferring is simply a matter of placing the oil or bromoil print in contact with a sheet of comparatively absorbent paper, that is, a paper which is not too heavily sized, and running the two together through a press such as an etching press or a clothes wringer. Almost any charcoal paper will work satisfactorily, and many other papers will be found useful, although the Japanese vellums and tissues are so soft in texture that the fibres are likely to adhere to the original and the transfer paper will be roughened in places when the two are separated. With care, however, very beautiful results may be obtained with such papers.

If it is intended to transfer, the oil or bromoil print should be inked with a comparatively thin ink, since a stiff ink will not adhere satisfactorily to the transfer paper. The use of a thin ink, as has been stated above, causes a granular appearance in the oil or bromoil print, but the operation of transferring modifies this to a great extent by spreading out the small spots of ink, thus giving a texture approaching the close texture resulting from the use of a stiff ink in straight oil or bromoil work. The outlines will not, however, assume the distinctness of those in an oil or bromoil which has been inked with a stiff ink. One of the ablest of the English workers in this medium told the writer that he uses the original bromide or oil print simply as an indication of the outlines, relying almost entirely on the brush action for securing the desired values, and stating that the ink employed is so thin that a 12 × 15 print is fully inked in ten or fifteen minutes. Rapid working is far more necessary if the print is to be transferred than otherwise

In order to prevent the print from sticking to the transfer paper it is sometimes advised to give the former, prior to soaking, an immersion of two minutes in a 1 per cent. formaldehyde solution, but the necessity for the formaldehyde bath may be avoided by allowing the water to dry out of the film slightly before transferring, the water drying out much more rapidly than the medium in which the ink is ground. A fairly heavy pressure should be used, although it is impossible to give any definite information on this point, since the pressure necessary will vary with the stiffness of the ink, with the quality of the transfer paper and

with the result desired. The transferred print will of course be reversed as regards right and left and allowance must be made for this in printing the original oil or bromoil if it is imperative that the completed picture be the right way around. If a clothes wringer is used the oil or bromoil print should be supported on a flat board or piece of sheet metal, and two or three pieces of blotting paper or of etcher's blankets should be placed over the transfer paper whether the clothes wringer or the etching press is used, since if this is not done uneven pressure may result, causing the ink to transfer more heavily in some portions of the picture than in others.

Most writers lay special emphasis on the fact that it is possible to modify relative values to an unlimited extent in oil or bromoil work, and this fact is obviously of primary importance, it being seldom the case that a direct transcript from nature is artistically satisfactory, but in the author's opinion the fundamental value of these processes is found in a deeper psychic quality than this. It is well known that the chief value of any graphic art, and even of the crafts, depends on the fluent and irregular action of the hand, the very precision of mechanical carving, for example, operating to render it uninteresting when compared with hand work. Photographers have felt this mechanical quality in the productions of the camera, and have endeavored to avoid it by brush-development of gum prints, by etching on the negative, and by other devices, but these are not satisfactory solutions of the problem, the results showing their hybrid character and, further, losing the greatest advantage of photography, the per-

fect rendition of outlines and gradations. Thus, in platinum, gum-platinum, and most other mediums we have either a print compounded of photography and hand-work—always an abomination —or one in which, beautiful though it may be in outline, gradation and tone, we always feel the machine, and the effect can never reach the highest pitch of artistic expression. The worker in oil, however, has at his disposal a medium in which he can render perfectly the imperceptible gradations of light on surfaces and the precise outlines of the subject, or can vary at will either outlines or gradations, all without losing the beauty of the photographic image, and, in addition, can by skilful manipulation of the brush and the ink vary the texture of the image in different parts of the print. A platinum print may be very beautiful, but it remains fundamentally a product of a machine, whereas an oil print necessarily possesses, to a greater or less degree, depending on the skill and feeling of the worker, the personal touch so prized by artists and art lovers, and may be so imbued with the personality of its maker as to rise to the very highest levels of graphic art.

CHAPTER XVI

TECHNIQUE OF PHOTOGRAVURE

THEORY.—A smooth copper plate is burnished and thoroughly cleaned and is covered with a fine dust of asphaltum powder, which is caused to adhere to the plate by heat. A carbon print is then made from a glass positive and transferred to the grained copper plate, stripped and developed. After the carbon print is dry, the plate is immersed in a bath of perchloride of iron, which possesses the property of dissolving copper. Since the carbon print consists of varying thicknesses of gelatine, the etching bath penetrates this film and attacks the copper under the thinnest portions of the film first, then under the next thicker and so on until it has etched the copper to a satisfactory depth under the thickest portions of the carbon print. Since the carbon print was made from a positive it follows that the print itself is a negative and the thinnest portions are in the shadows of the picture, consequently the copper is etched deeper in the shadows than in the half tones and deeper here than in the lights. Also, the copper is etched only where it was not protected by the grains of asphaltum powder, so that the final result after cleaning off the gelatine film and the asphaltum dust is a copper plate etched deeply in the shadows, less deeply in the half tones and least of all in the lights, but having only a certain proportion of its surface etched. This plate is then inked with an oily ink which is worked well into the little depressions made

by the etching fluid, and the surface is wiped with cloths and with the edge of the hand so as to remove all the ink from the surface, leaving that which is held in the little hollows. A sheet of paper is then laid in contact with the copper plate and pressure is applied to it. The result is that the paper is forced into the little depressions of copper and lifts the ink out, and since there was more ink in the shadows than in the half-tones—the former being more deeply etched—and more here than in the lights, a positive print is produced.

The Copper Plate.—This should be of the best grade of copper and should be bought already smoothed, burnished and bevelled, since although the worker can prepare the plate for himself, it involves too great an expenditure of time and effort to be worth while. The bevelling is not necessary unless the print is to be on a sheet of paper larger than the plate, in which case the paper will probably be cut unless the plate is bevelled. The plate should be approximately one-eighth inch thick for prints 8×10 inches, although lighter plates may be used for smaller prints. The surface should be examined to make sure that it is free from scratches or pits, since these, unless occurring in the shadows of the picture, will show in the finished print by reason of their catching and holding the ink. The plate should be cleaned with a solution of caustic soda or caustic potash to remove the grease and rinsed, after which it is cleaned with a dilute solution of sulphuric acid to remove the tarnish. These solutions are rubbed on the plate with a tuft of cotton, and rubber gloves should be worn during the operation. The plate is rinsed after

the treatment with acid and is then polished with Bon Ami applied in the same manner. After the cleaning it is rinsed and stood up to dry.

LAYING THE GROUND.—There are two methods of graining the plate, which are described below. The second is of comparatively recent development and in the writer's opinion is to be preferred to the other. For the first method a dusting box should be used, this being shown in Figure 44, the dimensions given being sufficient for plates up to 10×12 inches. Into this box is placed about one pint of finely ground asphaltum

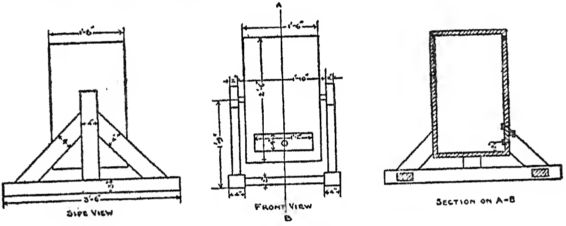


FIG. 44.

powder. The door is fastened on, and the box is rotated several times, the top, sides and bottom being beaten with the hand as the box is turned around in order that any particles of asphaltum which would otherwise adhere to the inside of the box may be dislodged. The box is brought to rest and bolted to hold it steady. The door is then opened and the copper plate is carefully introduced. The copper plate should be supported an inch or more above the bottom of the dusting box, an empty plate box serving to accomplish this, for should the plate simply be placed in the box and the dust

allowed to settle on it, it will probably be found on removing the plate that the dust has settled irregularly about the edges, this effect being explained as resulting from air currents set up within the box by the falling dust. This irregularity may be avoided by placing the plate on a sheet of glass an inch or so larger all around than the plate itself, when the irregularities will be on the glass instead of on the copper. The character of the ground depends to a considerable extent on the length of time that the box is allowed to rest before inserting the plate, and also on the length of time the plate remains in the box, since the coarser particles of dust naturally fall first, being followed by the finer ones. For a coarse ground the box may be allowed to rest for about twenty seconds before inserting the plate, and the plate may be allowed to remain in the box for four or five minutes. If a finer ground is desired the box may rest for one or one and a half minutes before the plate is inserted, but in this case so much of the dust will have settled that it may be necessary to insert the plate three or four times. The quality of the ground should be varied to some extent according to the character of the print desired, for if a fine ground is used it will not be feasible to produce a print with strong shadows, since the deep etching required would cause undermining of the little points of copper, and the shadows would fail to hold the ink properly. After the plate has remained in the box for the determined length of time it should be removed very carefully, as a jar or a breath of air will suffice to scatter the dust. The plate when examined should have the appearance of a fine cloth and the texture of the

ground should be uniform. Any large particles which may have fallen on the plate may be removed with a very fine-pointed brush slightly moistened with water. Should the appearance of the plate be unsatisfactory the dust may be wiped off with a tuft of cotton and another ground may be laid. When a satisfactory ground has been obtained the plate is grasped at one end in a small hand vise or pair of pliers, a slip of cardboard being bent over the edge of the plate in order to prevent injury to the copper. The plate is then held over a Bunsen burner or an ordinary gas stove and moved about until the ground is set. The setting of the ground may be determined by the fact of the dust first losing its dull appearance and becoming transparent, and afterward assuming a blue color. If too much heat is applied the dust may be melted and caused to run together, forming a uniform varnish over the entire surface of the plate, but the heat required to effect this with asphaltum is so great that there is little danger of such an occurrence, it being more likely to take place if rosin or copal is used, as is sometimes done. After cooling, the plate may be examined with a magnifying glass and if the ground is considered insufficient another may be laid over the first and set in the same manner.

The alternative method is to dispense entirely with dusting and to use instead a screen especially made for photogravure and somewhat resembling a half-tone screen. The carbon tissue is exposed under the positive and is then placed in contact with this screen under heavy pressure—a printing frame with pressure screws should be employed—and is then exposed to the same printing light for about half as long as was required to

print from the positive. The tissue is then transferred to a polished copper plate, stripped and developed in the usual manner, when the gelatine film will consist of a series of fine lines with the gradations of the positive superposed on them, these lines of insoluble gelatine serving to protect the copper from the etching bath in precisely the same manner as the grains of asphaltum. As has been said, the writer prefers this method to the other, since it is more rapid and more certain, the sole drawback being the cost of the screen, which, however, with ordinary care will keep in good condition indefinitely.

It is also possible to lay a ground by flowing the plate with a solution of rosin in absolute alcohol or by spraying this solution on from an atomizer. The writer has never used a liquid ground, and it is not in general recommended. One of the ablest of present workers has said: "I have found liquid grounds to be troublesome and unsatisfactory."

The Positive.—This may be made on a dry plate either by contact printing or by enlarging, and should have only a moderate degree of vigor, for if the positive is too strong the carbon resist will be as well and the plate will be over-etched in the shadows. In extreme cases this over-etching may be so great as to cause under-cutting of the copper where protected by the grains of asphaltum, so that the little hills of copper will break down and the shadows will have less depth than they should. It is also possible to make the positive by contact printing in carbon, transferring the carbon tissue to a piece of ground glass as indicated in the chapter on carbon printing. The transparency must be

provided with a safe-edge as in ordinary carbon work and any modification of relative values which may be desired should be made either on the negative or on the positive, since it is difficult to do any handwork on the copper plate or on the resist without such handwork being apparent.

THE RESIST.—The carbon print which is made from the positive and is developed on the copper plate is known as the resist, and a special tissue is provided for this purpose, the ordinary tissues being less suitable, although they may be used in an emergency. The tissue for the resist may be obtained in a bright red, a dark red, or a brown, the difference being that the lighter color makes it easier to watch the process of etching, whereas with the darker tissue it is easier to watch development of the resist. The writer prefers to use the lightest tissue, developing one print on a sheet of ground glass and modifying the time of printing or the temperature of the developing water for the resist, as may be indicated by the result first obtained.

The tissues may be sensitized by immersion in the bath for which a formula was given in the chapter on carbon printing and should be squeegeed to a ferrotype plate and allowed to dry in the dark, and the use of a ferrotype plate is of greater importance than for ordinary carbon work, it being imperative to keep the resist free from dust.

The writer times the printing of the resist by making a normal P. O. P. proof from the positive and printing the resist for the length of time required for proofing.

When the resist is printed it is transferred to the copper plate precisely as though the latter were a sheet

of transfer paper and if the work is properly done adhesion will be perfect, even though transferring is done directly on the burnished copper, as is the case when the screen is used. The backing is stripped off and the resist is developed as in the case of an ordinary carbon print, though every effort should be made to attain such accuracy of printing that the print may be properly developed at a temperature not exceeding 120° Fahrenheit or the film may strip off the copper when dried. The resist should be printed and developed in such a manner that the thinnest possible film of gelatine will remain on the copper in the shadows, without, however, losing any of the shadow detail, and it is for this reason that the writer prints a test sheet and develops it on ground glass, keeping a record of the temperature of the developing water. Care should be used to see that no particles of dust get between the copper plate and the resist or adhere to the resist while it is drying, since such particles will probably cause spots in the finished print. Drying of the developed resist should preferably be spontaneous and in reasonably good atmospheric conditions will be complete in the course of an hour or so, though if time is of importance the plate may be flowed two or three times with a 50 per cent. solution of alcohol in water, then two or three times with a 75 per cent. solution and may finally be immersed for two or three minutes in pure alcohol. After this treatment drying will take place very rapidly, but there is greater danger of the film stripping from the copper than if the drying is spontaneous. When the resist is dried the edges and back of the copper plate should be protected by means of asphaltum varnish thinned

with benzole, which may be applied around the edges of the resist with a fine ruling pen, a brush then being used to work up to this line and over the portion to be varnished. The varnish will dry in the course of two or three minutes and the plate is then ready for etching.

Etching the Plate.—If a single solution of perchloride of iron were to be used for etching it would penetrate the gelatine film so rapidly that the copper would be attacked in the high lights of the picture before it was deeply enough etched in the shadows, and although a single solution is sometimes used in the case of line work it is not satisfactory when a full scale of gradations is desired, and the process must in that case be modified somewhat.

It is a property of perchloride of iron that a strong solution of it will not penetrate a thick gelatine film, and advantage is taken of this circumstance in photogravure work. A fairly strong solution is used at first and this penetrates the thinnest portions of the resist, etching the copper under them, but does not penetrate the thicker parts. When this action has proceeded as far as it will—that is, has gone through the thickest film which it can penetrate—a weaker solution is applied and this penetrates the next thicker portion of the film, etching the copper under this, and at the same time continues the etching in the shadows. A still weaker solution is then used and this extends the action still further and so on, until the weakest solution has penetrated the thickest portion of the resist and has acted on the copper to the proper extent. Thus each solution intensifies the action which has already been begun and starts etching in gradations lighter than

those attacked by the preceding solution. Different writers recommend different numbers of etching baths, Herbert Denison advising six baths of the following strengths, the density being measured with a Beaumé hydrometer designed for heavy liquids: 45°, 43°, 40°, 38°, 36°, and 33°. Other writers say that a good general series is: 40°, 36°, 33°, and 30°. The range of density of the solutions depends on the result desired and on the quality of the transparency and the resist, since a resist having considerable density will require a weaker series than a thinner one, and a resist having little contrast will require a greater number of solutions than a stronger one, for obviously the greater the number of solutions applied the greater will be the contrast in the finished print.

To make the etching baths, take 7 pounds of perchloride of iron crystals, add 60 ounces of water and dissolve by gentle heat. Take 10 ounces of this solution and add stronger ammonia, a little at a time, until the solution becomes thick, then add this to the bulk of the solution and boil to expel the excess of ammonia. Allow this to stand for twenty-four hours, bring to a temperature of 70° Fahrenheit, and test it with the hydrometer. Should it not test 45° it may be boiled until it does so, the testing in each case being done at the temperature indicated. When it tests 45° Beaumé a portion is bottled and labeled. The stock solution is then diluted with water at 70° Fahrenheit (if cold water is used the perchloride may be precipitated) until the next weaker step is reached, when a further portion is bottled off, and so on until the complete range of solutions has been obtained. This will make about 16

ounces each of the six baths indicated above. It will be found that when this has stood for a time a sediment will form and the clear solution may be decanted or siphoned off. These baths improve with use and it is advised that a piece of copper wire be suspended in each of the bottles and allowed to remain for about fifteen minutes before they are used for the first time.

It will be found convenient to have six trays of porcelain, glass, or hard rubber, and to place the six solutions in these in regular order. The plate with the resist mounted on it is lightly dusted and placed in the strongest solution, the tray being rocked and the plate watched carefully. If the resist is too thick this solution may not penetrate the shadows at all and after three or four minutes the plate is lifted out, drained and placed in the next tray. If, on the other hand, the strongest solution penetrates the film—which it will do if printing and development have been correct—the copper will be seen to discolor, and if the red tissue is used for the resist there will be no difficulty at all in observing the action. This discoloration will be seen to spread over the surface of the plate, which should be allowed to remain in the solution until the discoloration has ceased to spread. When the discoloration has ceased spreading in each solution the plate is drained and transferred to the next weaker bath, where it remains until the time for its removal. It should be allowed to remain in the weakest solution necessary until the high lights have been completely discolored, when it is rinsed rapidly in hot running water and the softened resist is rubbed off with a tuft of cotton. The

asphaltum ground, if such was used, together with the varnish on the edges of the plate, may be removed with benzole and the plate is then cleaned with Bon Ami, after which it is rinsed in hot water and dried and is then ready for printing.

Great control over the finished result is possible through variations in the etching baths, for, as has already been indicated, a greater number of baths gives greater contrast, and if a soft result is desired etching may be commenced in a weaker bath than 45°, so that the number of baths is shortened.

If the resist is too dense it may be that the weakest bath will not penetrate the thickest portions of the resist and in that case the 33° solution may be diluted still further.

Printing.—The ink used for printing is that regularly supplied for photogravure work and may be of any desired color. It will have greater brilliance and richness if freshly ground, but for all practical purposes it will work satisfactorily if purchased in a collapsible metal tube from which the required amount may be squeezed as it is needed. Boiled linseed oil may be used for thinning the ink, which should ordinarily, when ready for use, have such consistency that when a small portion is lifted on the palette knife it can be prevented from falling off only by turning the knife around. A stiff ink will give a darker print than a thin one, hence it follows that considerable modification of result is possible through varying the consistency of the ink.

To apply the ink to the plate, a dabber will be required, and this may either be purchased from a dealer

in photogravure supplies or may be made as follows: A strip of heavy woolen cloth about six inches wide and perhaps three feet long has V shaped notches cut in one edge every few inches. The cloth is then wound up until the base is three or four inches in diameter, when the end is stitched fast. A cord is then wound around the neck of the dabber, the final shape of the instrument somewhat resembling that of a pestle. The base of the dabber may be sliced off with a sharp knife until it is even, and a piece of the same cloth is stretched over it and carried up the sides, being stitched in place. With continued use this covering will become stiff with old ink and may be replaced when necessary.

The ink is spread in a film on a sheet of glass or a palette and the dabber is pressed into it several times to insure its being thoroughly covered with the ink. The plate is then warmed over a gas flame until it is about as warm as the hand can bear and the dabber is worked back and forth over the surface with a rocking motion, in all directions, until the depressions in the copper are thoroughly filled with ink. A piece of coarse well-washed muslin about two feet square is then wadded up in the form of a ball and the surface ink is wiped off the plate with it, this being followed by wiping with a finer piece of cloth. The wiping muslin should be folded in such a manner as to present a smooth surface to the plate, and when the plate has been wiped thoroughly with the cloth, wiping is finished with the edge of the hand. Wiping in this manner will leave a slight tint over the entire plate, and should this not be desired the hand may be rubbed on a cake of Bon Ami and lightly wiped with a cloth and then be passed

over the plate, when the surface ink is thoroughly removed and the plate yields what is called a "natural" print. After wiping, the margins of the plate may be cleaned with a piece of chamois folded over the finger, and the plate is ready for printing. It will be found that the plate has become cool by this time and will give a darker print than if it is kept warm during wiping, the ink being thinner when warm, so that more is removed by the cloth. The use of a soft rag, greater pressure or slow wiping will give a lighter print than the reverse treatment, and considerable modification is possible by varying the treatment in these respects.

For printing, the etching press is advised, although if it is not desired to spend the amount of money necessary for such a piece of apparatus, a clothes-wringer may be used, but it will not be possible to make such large prints with this as with the regular press. The etching press is furnished with a metal bed-plate which travels between two rollers, and if a clothes wringer is employed it will be necessary to have a flat piece of stout wood or metal on which to rest the plate during its passage between the rollers. If the etching press is used the plate is laid on a sheet of zinc or paper which rests on the bed plate, the paper to be printed on is placed on the plate and several pieces of etcher's blanket are laid over the paper. The screws of the press are then screwed down to the proper point and the press is revolved by means of the handle. When the plate has passed through the rolls the blankets are lifted and the paper may be removed from the plate. It is impossible to give any definite idea as to the pressure required, but it should, roughly speaking, be so

great that considerable force must be exerted on the handles of the press in order to rotate the rolls. Greater pressure or the use of more blankets will give a darker print by forcing the paper farther into the depressions of the copper. It will probably be found that the first print is unsatisfactory, owing to the plate not having taken the ink perfectly, and a second proof should always be pulled before deciding on any variations of treatment. If the plate gives too dark a print an improvement may be made by the use of a thinner ink in addition to the methods given in the previous paragraph, and, as stated, a stiffer ink will give darker prints, so it will be apparent that great variations are possible.

Many different papers may be used for printing and the worker is advised to obtain a selection and experiment with them. Practically all papers, however, must be used in a damp state and this may be attained by soaking them in water, then placing two or three sheets between blotters and running them through the press, the excess of water being thus removed, or, if preferred, each sheet may be dipped quickly into water, the sheets being stacked and placed under pressure for several hours.

Modifications.—If the plate is to be strengthened as a whole a printer's roller may be used to apply what is known as "finishing ink." This ink may either be bought or be made up as follows, this formula being taken from Herbert Denison's "Treatise on Photogravure":

Asphaltum	1¼ ounces
White wax	3 ounces
Stearine	3¼ ounces
Spermaceti	7 ounces

The asphaltum is melted in a double boiler and the other ingredients are added in turn with constant stirring. When cool it will be stiff and may be thinned with turpentine for use. A small quantity is placed on a sheet of glass, the roller is passed over it several times in different directions until evenly covered with the ink, and is then passed over a clean sheet of glass until only a very thin film of ink remains. The roller is then passed lightly back and forth in different directions over the cleaned copper plate until the surface is lightly charged with the ink. If it is desired to leave the high lights in their original condition, strengthening the half-tones and the shadows, a little more of the ink may be taken up on the roller and applied to the plate, when the shallowest depressions will be filled with the ink and will not be affected by the application of the etching bath. If the high lights and half-tones are to be left unchanged and the shadows strengthened, a little more of the ink may be applied, so that the depressions slightly deeper than those in the lights are filled with the ink. After inking, the plate is thickly dusted with asphaltum powder and that which does not adhere to the ink is brushed off with a soft brush. The plate is then heated until the asphaltum becomes incorporated with the ink, the appearance of the plate being distinctly changed at this point. When cool the back and edges of the plate are protected with asphaltum varnish and the plate is re-etched for the desired length of time in a medium strength bath, afterward being cleaned and printed as before.

It is also possible to lay a ground on the cleaned copper plate in the dusting box and set it by heating,

after which a weak solution of perchloride of iron may be applied to such portions as it is desired to strengthen, by means of a soft camel-hair brush. The plate should be rinsed from time to time and dried with a clean cloth or there is danger of the mordant spreading where it is not desired. It is also possible to lighten areas by rubbing down the hills of copper with a burnisher or to darken portions by etching with a needle. These methods, however, are not recommended, since the handwork is very likely to be apparent and it is decidedly preferable to make necessary modifications on the original negative or on the transparency, even though this may necessitate etching a new plate.

Evidently, it is possible to make multiple prints in photogravure, by inking the plate and running the print through the press a second time. Some method of registration must be used, and this may conveniently take the form of pencil marks or scratches on the zinc or paper underlying the plate, a line being run around the copper plate and marks being made at the corners of the printing paper. Of course, the several printings may be in different colors, as in carbon and gum, and it possible to make photogravures in full color by printing from a set of plates made from a set of three-color negatives, though this requires a high degree of skill, combined with very careful manipulation.

PART IV

COLOR

CHAPTER XVII

DESIRABILITY OF COLOR IN PHOTOGRAPHY

Almost since the first discovery of photography scientists have been working to develop some method which would permit of reproducing not only the gradations of natural objects but also the colors, and within the past ten years considerable success has crowned their efforts, in that methods of color photography have become commercially practical. Before that time there had been discovered several methods which permit of accurate reproduction of colors, but color photography remained a laboratory experiment, or at least required laboratory apparatus and very careful work, until the introduction of the autochrome plate by Messrs. Lumière. Since that time several plates more or less resembling the autochrome in general character have been placed on the market, and Frederick Ives has standardized an older process in such a manner that any photographer who will follow instructions carefully can at the present time make satisfactory photographs in full color of practically any natural object.

There can be no question as to the scientific value of these processes, since they render possible a perfect record of many objects of the highest interest, scientists hitherto having been obliged to rely on the comparatively laborious and inaccurate method of hand coloring, so that to the botanist, the zoölogist, the patholo-

gist and to many other workers in scientific fields color photography renders inestimable assistance. So far as the artist is concerned, however, the value of color photography is more or less doubtful, and many arguments are advanced against its use in this field. The writer has at various times made a great many color photographs and, like nearly every photographer, was very enthusiastic over the process on his first introduction to it, but after making perhaps two hundred or three hundred color photographs he found that, the novelty wearing off, the results failed to interest him. In the search for a reason for this condition the writer has come to a very definite conclusion, that in the present state of the art the use of color is not desirable.

Some time ago, in conversation with two well-known painters, the writer said: "How much do you feel that photography loses by being unable to reproduce colors?" One of the painters answered, "I do not feel that it loses anything. If you examine the black-and-white reproductions of the works of the great masters you will find that in many cases the black-and-white version is more interesting than the original, and this is true even of the works of the Venetians, such as Titian," and turning to the other painter, he asked: "Isn't that so?" The other replied: "Absolutely; and if Titian's color couldn't make a thing interesting, nobody's could." Here, then, were two painters, both of them able men, both of them familiar with the best works in their medium, and both of them accustomed to work in color, who felt that a black-and-white art could, other things being equal, be quite as

THE CONNECTICUT RIVER
BY W. E. MACNAUGHTON
From a Platinum Print

interesting and as valuable as a color art. (The average layman is actually thrilled by the sight of a photograph in color, as witness the immense sale in this country of hand-colored prints, so it must be apparent that the layman and the artist are pleased by entirely different aspects of art.

To determine the cause of the different feeling which exists between laymen and artists, it may be well to consider first the appeal made by different forms of art, and it will be found that every art possesses in varying proportions an admixture of both sensuous and intellectual appeal. Thus, the appeal of music is almost entirely to the senses, the intellectual part being so slight as to be not worth considering; that of prose writing is almost entirely intellectual; that of poetry may be composed of intellectual and sensuous constituents in almost any proportion; that of architecture is almost exclusively intellectual, and so on. It is of course apparent that, whereas an intellectual appeal is to the logical faculties, a sensuous one is to the physical portion of the individual; that is, certain nerves respond to certain stimuli, thus affecting in greater or less degree the entire nervous system. It is well known that certain classes of music may stimulate the hearers to almost entire self-forgetfulness, inducing either tears or great exaltation, but it is not so well known that color possesses in lesser degree the same power. It has been found that the warmer colors, such as red, orange and yellow, stimulate the nervous system very markedly through the action on the optic nerve, so that no neurologist would permit a patient to remain in a room finished in red, whereas the cooler

colors are distinctly quieting to the nervous system. Hence it follows that the combination of different colors in their suitable proportions may produce a sensuous excitement or a sensuous calm resembling that aroused by music. It seems clear, then, that the function of color in art is to heighten the effect by producing in the spectator a nervous condition which renders him more receptive to the idea which the artist wishes to convey, and that when the artist wishes to appeal solely or principally to the intellectual faculties, he will refrain in great measure from the use of color, and will certainly employ only subdued colors. Examination of the works of those artists who are noted for their psychic insight, such as Rembrandt and Velazquez, shows that these men employed color to a very limited extent, their work being conspicuous for the use of secondary and tertiary colors, almost to the exclusion of primaries.

Since photography is capable of reproducing more perfectly than any other art the outlines and gradations of natural objects, and since it reproduces colors with comparative difficulty, it would seem that the worker with the camera is particularly favored if he desires to produce a result which shall appeal to the logical faculties rather than to the senses, and this serves to indicate the difference of opinion existing between artists and laymen as to the value of color in photography, for the artist is necessarily trained to observe and to think, whereas the average individual does neither. Many persons will be inclined to question this statement as to the failure of the average person to observe his surroundings and to employ his logical

faculties, but investigation shows that it is quite justified.

The photographer who wishes to work in color is, generally speaking, limited as to the ability to produce various effects, since he cannot modify the internal relationship of his colors with the same ease that the painter can and it therefore seems a mistake for a worker whose desire is to effect a sensuous stimulus to employ the camera, but the possibilities of appealing to the logical faculties by means of photography seem almost unlimited and the writer, therefore, feels that color photography does not merit serious consideration by the pictorial worker.

CHAPTER XVIII

THE TECHNIQUE OF COLOR PHOTOGRAPHY

All of the processes of color photography depend fundamentally on the fact that any color may be produced by the blending of two or three of the primary colors, the variations of method lying in the means employed for securing the desired result. In the autochrome, Paget, and kindred processes, the result is produced by interposing a screen of fine grains of the primary colors between a transparency and the illuminant, the photograph being examined by transmitted light. In the Sanger-Shepherd, Hess-Ives, three-color carbon, and three-color gum processes, prints are made in suitable dyes or pigments from a set of three negatives, each of which has recorded only one of the primary colors, the superposition of these three prints giving a reproduction of the original subject.

The Autochrome Process.—This is perhaps the simplest of the color processes and is the easiest to manipulate. The plates, which are obtainable commercially, are made in the following manner: Starch grains approximating 1/1500 inch in diameter are dyed in the three primary colors, being afterward mixed in suitable proportion and attached firmly to a glass plate. Pressure is then applied so that the starch grains are flattened out and any interstices are filled by the spreading of the grains. A panchromatic emulsion is then placed over this color screen and the plate is ready

for exposure. It should be taken from the package in absolute darkness and placed in the camera with the glass side toward the lens, so that the light must pass through the color screen before reaching the sensitive emulsion. Black cards are furnished with the plates and one of these should be placed in contact with the emulsion before loading the plate-holder, since the emulsion is much thinner and more delicate than that on an ordinary plate and scratches or pin-holes cannot be spotted out with the facility that is possible in ordinary photography. A special ray-filter must be placed on the lens and allowance of course must be made in focussing for the fact that the emulsion is farther from the lens than is ordinarily the case. The exposure is much longer than with ordinary plates, approximately sixty times as much exposure being required as with a Kodak film. The latitude of the emulsion is much less than that of an ordinary plate and exposure must be very nearly correct or the color rendering will be decidedly faulty, 10 per cent. in either direction being enough to introduce serious defects in the finished result.

If we consider one particular color it will be easier to follow the theory of the subsequent processes, so we will fix our attention, say, on an area of red in the subject, which occupies perhaps half a square inch on the plate. Each of the colored starch grains acts as a filter, the violet and green absorbing the red rays completely before they reach the sensitive emulsion, the red grains, on the other hand, permitting the red rays to pass freely. Hence it follows that the red light reflected from the subject affects the sensitive emulsion only directly over the red grains and on development

we have a deposit of metallic silver over the red grains, while the silver bromide remains unaffected over the violet and green grains. When development is complete, the plate is immersed in a solution which dissolves metallic silver but does not attack the unreduced haloid salt. The plate is then exposed to light and is again developed, with the result that there is a space of transparent gelatine over each red grain in the area under consideration and an opaque deposit of metallic silver over each violet and green grain, so that on holding the plate up to the light the area in question will appear red by reason of the fact that the red starch grains absorb the violet and green components of white light, permitting only the red rays to pass through. A like result occurs in the case of violet and green objects, and since we have found that secondary and tertiary colors, such as blue, yellow, brown, etc., are made up by a suitable mixture of two or more primaries, it follows that the colored starch grains sift the primaries reflected from natural objects and the appearance of the subject is thus reproduced not only in gradation but also in color.

It is possible to correct to a certain extent errors of exposure by variations in development, for if the plate be developed entirely by time the effect of over-exposure is to give blank high lights, whereas under-exposure results in general heaviness. There are many methods given for effecting this correction, most of them being based on the time required for the image to appear in the developer. Since the emulsion is panchromatic, the light permissible in the dark room is of a very dim green nature and it is difficult to follow

the process of development by inspection, so for this reason the writer prefers to desensitize the plate by immersing it for five minutes in total darkness in a bath of

Water	10 ounces
Potassium metabisulphite	½ ounce

after which it is rinsed for about thirty seconds under the faucet and development is carried out by an ordinary red light. Any standard developer may be used, although pyro is not advised, as this gives a general warm tone. For the sake of convenience the writer prefers to use rodinal or the metol-hydroquinone formula given in Chapter IV, using about one ounce of the stock solution to fifteen ounces of water. It is impossible to state definitely just how far development should be carried, as experience is the only certain guide, but generally speaking it should be continued until the high-lights have apparently begun to grow thinner; that is, the lights will gain in density at first and after a time will assume a slightly grayish appearance, this being the point at which development should be stopped. The plate is then rinsed under the faucet for about thirty seconds.

The next step is reversal, and numerous formulæ are given for this purpose, the function of the reversing solution being to dissolve out the metallic silver resulting from development. The formula which the writer prefers is as follows:

Water	7 ounces
Potassium bichromate	25 grains
Sulphuric acid, dilute	7 drams

This is less likely to cause black specks than the usual potassium permanganate formula. The plate is

allowed to remain in this solution for about five minutes in all, and after a minute or so in this bath should be carried out into daylight, the light of an ordinary room being sufficient. If development takes place at night the plate may be exposed for five minutes a few inches from a strong light, such as a Welsbach or incandescent electric lamp. If preferred, the plate may be rinsed after five minutes in the reversing solution and set up to dry, the subsequent operations being carried out at any later time, and this technique possesses the advantage of diminishing the likelihood of frilling.

After reversing, the plate is rinsed for about thirty seconds under the faucet and is then redeveloped for about five minutes in the original developer, after which it is rinsed for thirty seconds under the faucet and set up to dry.

When dry the emulsion should be flowed with the special varnish provided by the manufacturers of the plate, since this tends to preserve the purity of the colors and to protect the film from injury. After varnishing, the plate should be bound up with a cover glass after the fashion of a lantern-slide, and may then be depended on to remain in satisfactory condition for an indefinite length of time, though if it is exposed to direct sunlight or to great heat for prolonged periods the colors may fade or the film may crack.

The chief causes of failure in autochrome work are over- and under-exposure and frilling. This last will probably not be serious if all the solutions are kept at a temperature between 60° and 65° Fahrenheit and the plate is not handled with the fingers. It is therefore advised to be careful regarding temperature and to

allow the plate to remain in one tray as much as possible during all the processes, but if the temperature cannot be kept at the proper point immersion of the plate for two or three minutes in a 5 per cent. formaldehyde bath, followed by rinsing, will help matters. The formaldehyde should be used before desensitizing.

If a developer which works without alkali is employed the likelihood of frilling is still further reduced, and many photographers prefer amidol and dianol for this reason. Scratches on the film may cause green spots through permitting the developer to penetrate to the color screen and causing the dye in the starch grains to run. Black specks may sometimes be removed by the use of the reversing solution applied with a fine pointed brush, but retouching is in general exceedingly difficult and uncertain. Any of the methods of intensification or reduction given in Chapter VI may be used with autochrome plates, but it should be borne in mind that the film is exceedingly thin and any solution which is employed should be diluted to approximately one-tenth the concentration at which it is used for general work, or the action will be so rapid as to make control difficult.

The Paget Process.—Fundamentally, the Paget process is identical with the autochrome but differs from it in that the color screen and the sensitized emulsion are on different pieces of glass. The sensitized plate is first placed in the holder and the color screen is laid over it, the exposure being made as with the autochrome plates. Development may be either by time or by inspection, and the plate is washed and dried in the usual manner, the color screen being

preserved for subsequent use. From this negative a transparency is made on a dry plate by contact printing and it is possible to compensate to a considerable extent for errors in exposure and development during the process of making the transparency. This transparency is then registered with a special viewing screen similar to the taking screen, though differing from it somewhat in the adjustment of the colors, and the two are bound together with passepartout tape or lantern slide binding. It will be seen that the Paget process is capable of giving any number of duplicates, since the color screens are regular and any number of identical viewing screens may be bound up with transparencies.

The autochrome and Paget processes differ not only in the possibility of duplication which exists in the latter, but also in the fact that the color screen in the Paget plates is far more transparent than in the autochromes, since it consists simply of aniline dyes laid on the transparent substratum, no starch grains being used. The results are therefore far more luminous than any autochrome can ever be.

A disadvantage of the Paget process lies in the fact that the glass plates must be carefully selected for flatness, since unless the films of both negative and positive plates are in optical contact with the color screens it will be impossible to secure satisfactory results. One worker advises cementing the transparency and the viewing screen together with Canada balsam thinned with xylol, a small pool of the cement being poured on the screen and the transparency pressed on it so as to force the balsam over the whole surface. The two are then held up to the light and the transparency is moved

about until register is secured, the plates being then clipped firmly together and placed in a warm oven until the balsam is hard, when the whole is bound up with tape. This plan is said to insure the avoidance of parallax and make possible the use of transparency plates which are not optically flat.

The Hess-Ives Process.—As has been said, the Hess-Ives process is fundamentally identical with a well-known and comparatively old method of color photography, the improvements consisting of a means whereby all three of a set of three-color negatives may be made with one exposure in an ordinary camera, and the standardization of the subsequent operations so that they may be carried out with precision by any reasonably careful worker.

In its original form this process required a special camera, but a later improvement has done away with this, and any camera may be employed, the only special apparatus necessary being a plateholder. In this holder is placed a pack consisting of a red-sensitive plate, a green-sensitive film, and a blue-sensitive plate, firmly bound together, the film being between the two plates. The blue-sensitive plate is toward the lens, and when exposure is made this plate records the violet element of the light forming the image, permitting the green and red rays to pass through the emulsion. The green rays affect the sensitive emulsion on the film, which in turn allows the red rays to pass through and reach the red-sensitive plate. The exposure required is somewhat less than for the autochrome plate, which is rated at F/14 on the Wynne meter, the speed of the Hess-Ives pack being about F/20.

The three plates are developed for a standard time in a standard developer at standard temperature, the time of development being variable for special effects if so desired, or factorial development may be used.

The three negatives are printed similarly on a bichromated gelatine film which is supported on transparent celluloid, and the printed film is developed in hot water, with the result that certain portions of the gelatine are dissolved off from the support exactly as is the case in carbon printing. The films are then dyed in suitable dyes, each film of course taking up an amount of the dye proportionate to the amount of gelatine remaining on the support, and the three dyed films are then bound up in register, a transparency in natural colors resulting.

If a print on paper is desired one print is made on paper, the other two being on celluloid and the three being cemented firmly together. It will be seen from this that the Hess-Ives process presents one conspicuous advantage over the autochrome and Paget processes, in that it gives prints which may be examined by reflected light, the other processes requiring transmitted light for examination of the result. Also it has the advantage over the autochrome process that any desired number of prints or transparencies may be made from a set of negatives, and a further advantage is that relative modifications of color may easily be made by dyeing one film more strongly than the others, or by brush-work in any particular area of any of the films, this last-named quality being of great value to the pictorial worker.

To give full details of the Hess-Ives process would

occupy more space than can be afforded in a book of this nature and would furthermore be superfluous, since these can readily be obtained from the manufacturers. It may, however, be said that this process is strongly to be recommended to the pictorial worker who desires to employ color, and for this purpose is the most desirable of all, with the possible exception of three-color gum, the chief drawback of the Hess-Ives method lying in the fact that the surface-texture of the print is always approximately that of a collodion print, it being impossible to use a rough-surface paper as a support.

Three-Color Gum.—If a set of three-color negatives is made, using a suitable ray-filter so that one of the plates records only the red element of the light reflected from the subject, another only the green element and the third only the violet element, it is possible to print from these plates in suitable pigments, superimposing the second and third printings on the first, with the result that a completed print shows an approximately correct reproduction of the object photographed. The printing may be either in gum or in carbon, but the former is to be preferred for several reasons. First, it permits of a more accurate balance among the pigments, the filters and the plates, such a balance being necessary for correct rendering of color. Second, it permits the use of a paper base of practically any desired texture, whereas if carbon tissue is used the support must be smooth, since the print must be made by double transfer, single transfer not allowing the worker to determine whether or not the three tissues have been properly exposed and developed

until the print is complete, when it is too late to make any changes. Third, it is easier to introduce local modifications of color in gum than in carbon, this being sometimes desirable for pictorial effect.

There are two methods of making the set of three-color negatives, the first involving the use of three panchromatic plates, one for each color sensation record the second using different types of plates for the different records; that is, a panchromatic for the red sensation, an orthochromatic for the green sensation, and an ordinary for the violet sensation. The first method has the advantage that it is easier to obtain identical gradation in all three negatives, since the quality of all the plates in one batch is identical, whereas the quality of different emulsions varies widely. The second method has the advantage that it is not necessary to adjust the absorption of the filters with such great precision as in the first case, for it is apparent that if the violet screen transmits some red light, this will affect a panchromatic plate but will not affect an ordinary one, and the like is true of the green sensation filter. However, if the filters are carefully made by experienced manufacturers they may be counted on to do the work satisfactorily, and the writer prefers to use panchromatic plates for all three negatives on account of the greater facility in handling.

In making the exposure some arrangement must be used whereby the three filters can readily be substituted for one another in front of or behind the lens, and such fittings are obtainable commercially. It is convenient, though not necessary, to have a sliding back, so that the plates may be shifted along to be

exposed one after the other without the necessity for changing plate holders, but even without such a fitting the writer has made indoor portraits, the total time required for changing the plate-holders and filters and for the exposures being about two minutes, a time which compares very favorably with the exposure required in similar conditions on an autochrome plate.

It is necessary to use a corrected lens, preferably an anastigmat, since if the lens has any chromatic aberration the three images will not all be in focus and will not all be of the same size, thus rendering even reasonably good definition impossible. The lens should preferably be as fast as possible in order to reduce the time required for exposure.

For accurate work, such as reproduction, the filters should be of the class known as "optical flats" since a slight variation in the parallelism of the two sides of the filter is sufficient to introduce variations in the sizes of the three images. For pictorial work, however, such expensive filters as these are not required, and the writer has done perfectly satisfactory work using filters which consisted of dyed gelatine films, not even cemented but merely bound between lantern-slide cover-glasses. Still, such extremely inaccurate methods are by no means advised and the filters should be at least reasonably good ones. It will be found that very different times of exposure are required with the different filters and the relative increase dependent on each filter should be obtained from the manufacturer, since the multiplying factor varies with different batches of emulsion. At least one manufacturer in this country supplies this information with each box of plates.

Development should be by time, and if panchromatic plates are used for all the negatives, they should be developed simultaneously in a tank, since identity of gradation is thus insured.

Whatever method of development is employed the negatives should be much softer than for ordinary black-and-white work and should be somewhat softer even than the negatives for ordinary gum printing. It is well to make on the corner of each plate some mark of identification before the plate is developed, since the three negatives will be closely similar and it will not be easy to distinguish one from another.

The worker who wishes to print in three-color gum will probably do well to employ the Hess-Ives process for making the negatives, since it is much easier to produce a set of three-color negatives by this method than by making separate exposures with filters.

It is necessary to print each plate in a color complementary to that of the taking filter, as may readily be understood when we consider that the filter transmits light of its own color and that the blank spaces in the negative represent the absence of this particular color; that is, in the violet sensation negative the deposit of silver is caused by violet light and where there is no deposit of silver its absence is due to the fact that the filter absorbed the green and red components of the light reflected from the subject. Therefore the violet sensation negative must be printed in yellow (green + red) and similarly the green sensation negative must be printed in magenta (violet + red) and the red sensation negative in blue (violet + green). It is not possible to give a definite formula for the coating mix-

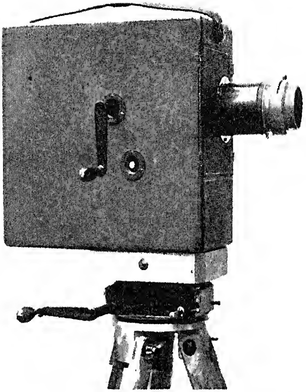


FIG. 45.—EXTERIOR OF MOTION PICTURE CAMERA

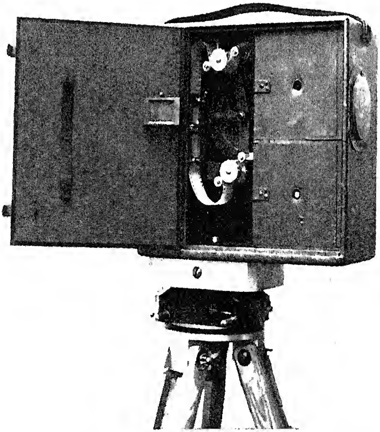


FIG. 46.—MECHANISM OF MOTION PICTURE CAMERA

tures, since this will depend on the subject, on the method of making the negatives, and on the filters used, but the manufacturers of supplies for the three-color process furnish ink testers or color charts which show the color to be used for each printing, and the worker can match these colors by combining different pigments. The pigments should, of course, be transparent ones rather than opaque, and it is usual to make the blue printing first, since this color is, generally speaking, less transparent than yellow and magenta. In some cases it will be found that a blue-print will serve for the printing of the red sensation negative and this simplifies matters somewhat, since a blue-print is easier to make than a gum print.

In order to obtain the proper gradations and depth it may be necessary to print twice or more in each color, and it will often be found that a light printing of black from a fourth negative made with a corrective filter will be helpful, since, although the three printings of blue, yellow, and magenta should theoretically give a black where such existed in the original subject, practically they will not do so, owing to the impossibility of obtaining theoretically perfect pigments.

Enlarged negatives may, of course, be made when large prints are desired, and although errors in these may be corrected to a great extent in printing, it will nevertheless be found advantageous to make the three large negatives as uniform with the originals as possible, since much trouble is thus avoided.

The three-color gum process is an exceedingly laborious one and in the writer's opinion the result does not repay the effort expended, though the worker who de-

sires color prints and is willing to give the time necessary to their production will probably find this process more satisfactory from an artistic standpoint than any other.

Since writing the above remarks, the writer has learned that the Hess-Ives Corporation is working on a standardized method for three-color gum printing, which should prove very valuable to the pictorial worker in color.

Multi-Color Gum Printing.—Some workers endeavor to produce striking effects by printing in arbitrarily chosen colors from a single negative, shading portions of the negative while printing one color and the remainder of the negative while printing the other colors, or removing the first color from certain areas of the print by scrubbing with a stiff brush and allowing these portions to print in the second or third color, these in turn being removed from areas where they are not desired. The writer has never seen a print of this sort which possessed any artistic merit whatever or could be considered anything except thoroughly unsatisfactory.

PART V

MISCELLANEOUS

CHAPTER XIX

PHOTOGRAPHY BY ARTIFICIAL LIGHT

In many cases it will be found necessary or desirable to make photographs at a time when daylight is not available for exposure, and when this occurs recourse may be had to one of several forms of artificial illumination, each of these having some special merit of its own.

The Mercury-Vapor Arc.—This consists of one or more glass tubes of a length determined by the class of work for which it is intended, these being filled with mercury vapor at comparatively low pressure. A current of electricity is passed through the tube or tubes and these glow with a high luminosity somewhat resembling that of the familiar Crookes tube which in modified form is used for X-ray work. Exposures of fairly brief duration may be made in certain circumstances by this illuminant, it being greatly in vogue for portraiture, and when used for this purpose permitting exposures of about five seconds with a lens working at F/8 and a moderately fast plate. The usefulness of this form of lamp, however, is restricted by the well-known law which says that the amount of light falling on the subject varies inversely as the square of the distance from the source of illumination, though for home portraiture it is in some cases to be recommended, since it is made in a convenient portable form and can be attached to any lamp socket, the current consumption being small.

The character of the light given by the mercury-vapor arc is, however, very different from that of daylight, since the lamp in question emits practically none but ultra-violet and violet rays, being devoid of red and green waves. Therefore correct color rendering must not be expected if the subject contains any red or green, even though a panchromatic plate is used. For this reason the writer prefers not to employ the mercury-vapor arc for portraiture, although it is exceedingly valuable for enlarging, lantern-slide work, and contact printing, the writer having made platinum prints from an average negative with five minutes' exposure a foot or more from a two-tube lamp of this character, so it follows that to a person whose photographic work must be done largely at night, the mercury-vapor arc will be of great assistance.

Incandescent Gas.—The Welsbach light furnishes a very desirable type of illuminant for portrait work, since it approximates more closely the composition of daylight than is the case with any other of the familiar lights. Since, however, this light is relatively richer in red rays than daylight, comparatively brief exposures are possible if panchromatic plates are used, a single Welsbach mantle six feet from the sitter giving sufficient illumination to permit of full exposure in ten seconds with a fast panchromatic plate and a lens working at F/8, whereas if an orthochromatic plate is used two minutes may be required. Increasing the number of mantles of course decreases the time necessary, and some photographers prefer to employ for night-work a frame carrying half a dozen or more Welsbachs, these being connected with a gas outlet by means

of a flexible tube, so that the frame may be moved about. Where possible to arrange, this is highly to be recommended, although it is not so convenient for home portraiture as the mercury-vapor lamp. Since the Welsbach light, as has been said, is relatively richer in red rays than daylight, good color values may be obtained without the use of a filter.

Flash-light.—In many cases it will be necessary to employ flash powder, and generally speaking the compound powders are preferable to powdered magnesium, since they give a more intense illumination and much less smoke and dust. Two cautions may well be given to the worker, the first being that the compound powders should never be used in a closed lamp such as is employed for magnesium, for they are explosive and if detonated in a closed space a serious explosion may result. They should, therefore, in all cases be used in an open pan and should be handled with the same care as would be given gunpowder, being preferably fired from a distance by means of electricity, many forms of apparatus being available for this purpose. The second caution is that the photographer should never attempt to make his own flash powder, since unless handled with knowledge and care these powders may be detonated during the process of mixing. It will be found that some powders give greater illumination and less smoke, weight for weight, than others, and such are of course to be preferred. It is impossible to give definite directions as to the amount of powder to be used in any particular circumstances, since this of course varies with the plate, diaphragm, character of the subject, distance of the subject from the flash and

kind of powder used. Two experiences of the writer's may, however, prove helpful and they are as follows: The first was a bust portrait of a single individual, the plate was a Standard Orthonon, the lens aperture was F/7.5 and 1½ grams (about 22 grains) of powder were used. In the second case a large gymnasium crowded with people was to be photographed and the plate was a Seed's L Ortho Non-Halation. The lens aperture was F/16 and 30 grams (about 1 ounce) of powder were used. In each case the plate was fully exposed.

For portrait work flash sheets will be found satisfactory provided the sitter can be depended on not to move, since these require about one second to burn instead of approximately one-twentieth second as is the case with flash powder. It is claimed that sheets give a broader and more diffused illumination than powder, but the writer generally prefers powder, since this may be made to give either a concentrated light or, by spreading it out in a long train, a broad flare, and is thus more under the operator's control.

Most flash-light portraits show a staring, unnatural effect in the eyes, but this may be avoided, the effect in question arising from the fact that the worker, prior to setting off the flash, either turns low or extinguishes all lights in the room so that the sitter either closes his eyes, unconsciously bracing himself against the nervous shock of the flash, or else opens his eyes wide to see as much as possible by the dim illumination remaining. In the latter case the pupils of the eyes dilate, this adding to the staring effect. If the ordinary lights remain turned on full during the entire time of making the exposure neither of these undesirable results will take place

and the staring effect will not be found in the print. There need be no fear that the lights in the room will have any bad effect, since they will not ordinarily furnish enough illumination to act on the plate during the brief time that the lens is open.

OTHER ILLUMINANTS.—What has been said of incandescent gas is, broadly speaking, true of the metallic filament electric light and is to some extent true as well of the ordinary oil lamp and of the carbon filament electric, since these give good color values without the use of a filter. However, the illumination resulting from these sources is so weak that exposures must be much longer than with other types of lamp. The writer on one occasion made a bust portrait by the light of a flat wick kerosene lamp about three feet from the sitter; the plate was a panchromatic, the lens aperture was F/6.8 and the exposure, which was approximately correct, was five minutes. With a round wick lamp this might have been diminished by two-thirds. No definite instructions can be given for photography by street lamps or by theatrical illumination, although it may in general be said that in such cases the use of a panchromatic plate is advised, since much briefer exposures are then possible than with the ordinary or the orthochromatic plate. If the source of illumination is included in the picture a non-halation plate should be used.

When it is possible to employ the large Mazda lamps as can often be done in studio work, these will be found very satisfactory. The writer has secured fully timed negatives on a fast panchromatic plate, with the lens working at F/5.5, in one or two seconds, when using a 1000-watt Mazda, with a 500-watt lamp of the same type as a supplementary illuminant.

CHAPTER XX

MOTION PICTURE PHOTOGRAPHY

The term which we frequently hear applied to motion pictures, that is, moving pictures, is a misnomer, since the picture seen on the screen by the observer does not actually move but is as stationary as any print may be. The illusion of motion is due to a phenomenon known as the persistence of vision, the result of which is that an object which is observed for a small fraction of time and then is suddenly removed from the spectator's range of vision apparently continues to be seen for an appreciable time after it is removed, the retinal image not fading at once. In motion picture work an object in motion is photographed and a fraction of a second later is photographed again, when it obviously will have moved through a short space. A fraction of a second later it is again photographed in a succeeding phase of motion, and so on for as long as may be necessary to show the complete movement. From this series of negatives transparencies are made on a long strip of film and are projected in sequence on the screen. The observer fails to recognize the obscuring of one phase of the motion during the time that another is being brought on the screen and thus an illusion of continuous motion is produced.

In practice this result is attained as follows: A long strip of film is so arranged that it may be wound past the lens with an intermittent motion. During

the period of rest the shutter is opened and the exposure made, the shutter is then closed and the film is jerked forward a short distance, when the shutter is opened again and another exposure is made and so on for as long as it may be desired to continue the operation, within, of course, the limits placed by the amount of film which it is possible to arrange in the magazine of the camera. Figure 45 shows a typical motion picture camera and Figure 46 shows the general arrangement of the mechanism. In the back of the camera are placed two retorts, the upper one carrying the unexposed film. From this retort the film is carried through a velvet-lined slit, which of course is light-tight. From this it passes over a sprocket, being formed into a loop the purpose of which is to insure flexibility of motion and to prevent dragging of the film. The teeth in the sprocket engage in perforations along the edges of the film, as do also claws which operate by a cam, the claws serving to drag the film forward during the period when the shutter is closed. The film passes over a small plate which insures contact between the film and the gate, the latter being the opening behind the lens through which the exposure is made. After leaving the gate the film is formed into a second loop and passes over another sprocket, whence it is wound into the retort for exposed film at the bottom of the camera. The shutter is in the form of a rotating wheel part of which has been cut away so that it alternately opens and closes the lens. The entire mechanism is operated by a crank and the customary rate at which the crank is turned is two revolutions per second, the gearing being so adjusted that sixteen exposures per second

are made on the film. Since the standard opening of the gate is one inch wide by three-fourths inch high it will be seen that at the usual rate of turning the crank one foot of film per second is used, so that a camera having a retort capacity of one hundred and fifty feet of film is capable of continuous operation for two and a half minutes without reloading and one having a retort capacity of four hundred feet of film may be operated for approximately six and a half minutes.

The price of a motion picture camera varies as widely as with the case of ordinary cameras, the extremes of cost being about $25 and $400, the higher priced instrument being of course more finely made and having special adjustments. As an example of the latter may be mentioned the shutter, which in the cheaper camera consists of approximately one-half of a complete disk of metal so that the exposure is necessarily one thirty-second of a second so long as the crank is turned at the normal rate of speed, whereas the higher priced cameras have adjustable shutters so that the exposures may be varied considerably from this standard in case the light or the speed of motion of the subject requires longer or shorter exposure. Also, the more expensive cameras have often a special gearing so adjusted that each revolution of the crank makes one exposure, this being designed for the production of trick pictures or for photographing exceedingly slow motions, such as the growth of a plant, when the exposures are made at intervals of several minutes or perhaps several hours. Of course the photographer's pocket-book will determine to a great extent the make of camera which he will use, but certain fundamental

desiderata may be indicated. The camera should be provided with a balance wheel heavy enough to insure even and regular motion of the crank, since it is not easy to turn the crank with perfect regularity until considerable experience has been gained. The lens should be of the fastest type obtainable, a speed of F/3.5 being none too fast for poor light conditions, and it is of course always possible to stop down when the quantity of light would mean excessive exposure at full aperture. The mechanism should be so designed that it is easy to thread the film through the sprockets and the gate rapidly, and it is of course as necessary with this camera as with any other that the box be light-tight. The gearing should be positive in its action and not likely to slip, and if the camera is to be carried about from place to place, it should be as light as possible. The tripod should be substantial and rigid, this being even more necessary than in ordinary photography, since the strain put on it by the turning of the crank is much greater than in the case of ordinary still work.

Exposure.—The film having been threaded up and the camera set up on the tripod, it becomes necessary to determine the proper exposure. Of course if the shutter is of the type having a fixed opening, the only variation possible is that due to opening or closing the diaphragm of the lens, and the same factors which control the question of diaphragm and exposure in ordinary photography are equally operative here, so that the Burroughs Wellcome note-book may be used for this purpose, simply bearing in mind that in this case it is the exposure which is fixed and the diaphragm

which varies. It will be found that for many classes of subject a lens working at F/3.5 will allow the passage of sufficient light to permit of using a three times or a five times ray-filter, and as a rule this should be done whenever possible, since better values are thus obtained and the pictures are more convincing. For indoor work this, however, will rarely be possible. When the exposure and the diaphragm have been determined, the next step is to focus on the subject, and this is done in one of two ways. Some lenses are provided with a scale so that focussing is done in the same manner as with the folding film camera; that is, by estimating the distance from the camera to the subject and setting the lens the proper distance from the film. Other instruments, however, have a focussing tube extending from the back of the camera to the gate, through which the operator may look to see whether or not the image is accurately focussed on the film, a magnifying lens usually being placed in the tube to increase the apparent size of the image. When the focussing has been satisfactorily completed and everything is prepared the crank should be given a few turns to insure that all the film which was exposed to light during the threading up has been wound past the gate, and exposure may then be begun. The crank should be turned regularly and steadily at the rate of two revolutions per second until the desired length of film has been exposed, which point is shown either by the desired amount of motion having been photographed, by a film indicator which is provided with the better cameras, or by the fact of the operator's having counted the desired number of feet, which may easily be done by remembering that

two turns of the crank expose one foot of film. Some cameras, indeed, are provided with small electric motors operated by dry batteries, or with compressed air motors, the cylinders being filled with air by means of a bicycle pump, and this type of camera is exceedingly valuable in natural history work or work in unusual locations where a tripod cannot be employed, since an instrument of this kind can be used in the hand after the manner of a Graflex or Kodak. Such instruments, however, are necessarily expensive, and the standard motion picture camera is operated by means of a hand crank. When the desired amount of film has been exposed the motion of the crank is stopped and the remainder of the film can be exposed on some different subject, or if desired the film can be cut and the retort containing the exposed film be replaced by an empty one, the remainder of the film being threaded up and further exposure being made at some subsequent time. This is done when it is necessary to develop the exposed portion of the film at once, as in topical or news work.

When the retort for unexposed film is empty it may be shifted to the lower position in the camera, thus preparing it for the reception of exposed film, a loaded retort taking its place above.

During the time of exposure the subject should be watched in the view-finder, which may be either the direct type consisting of a negative lens with a sighting rod, or may be the box type familiar to everyone who has used a folding film camera. Choice between these types is purely a matter of individual preference, some finding it easier to manipulate the crank while follow-

ing the subject in one type than is the case with the other.

Tripods having what is known as a panoramic and tilting top are obtainable, the top of the tripod being arranged in such fashion that by turning a crank the camera may be tilted either up or down, and turning another crank rotates it about a vertical axis. This form of tripod is very convenient for many purposes and is in general use by professionals, but for amateurs' use it will seldom be required and is unnecessarily expensive.

Development.—For developing the exposed film the most approved arrangement is a frame like that shown in Figure 47. This may be made of light wood by any carpenter or by the photographer himself, and should be soaked for an hour or so in melted paraffine, drained, and allowed to dry before use. The end pieces should be round, the movable one, however, having square ends, and a row of small brads should be driven into each, as indicated in the sketch, to keep the sections of the film separated. If one end of each of the side pieces is slotted and furnished with a helical spring so as to put a slight tension on the film after it is wound on the frame this frame may be used for drying as well as for developing and fixing, hooks on the side pieces serving to keep the end piece in its retracted position while the film is being wound on the frame. It is, however, better to wind the film off on a drum about three or four feet in diameter and five feet long to dry, since by this means sharp bends in the film are avoided. To develop the film the retort is taken into the dark room and the free end of the film is fastened to one of the

end pieces of the developing frame by means of a thumb-tack or a push-pin. The film is then wound on the frame, the latter being rotated on its trunnions as the film is drawn from the retort. When all the film has been wound on the frame, emulsion side out, of course, the end is fastened by means of another pin, the frame is lifted from the stand and is lowered into the tank of developer. In winding the film on the frame it is ad-

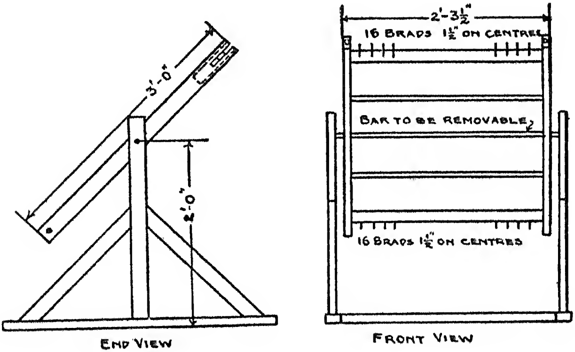


Fig. 47.

vised to draw it from the retort as it is wound, since if the film is taken from the retort and allowed to lie loose on the table or work-bench it is apt to kink and become unmanageable.

The developing, fixing, and washing tanks should be so arranged that the developing frame may be placed in them vertically and they should be furnished with guides to support the ends of the frame and keep the

film from touching the sides of the tank. These tanks may be made of wood and should be well coated inside with paraffine. Three will be needed, each of them three or four inches deeper than the frame and perhaps four inches wide.

The same laws which govern the exposure and development of any plate or film apply also to motion picture work, and any developer which the photographer prefers may be used for this purpose. It should be observed, however, that much of the professional motion picture work shows over-development of either the negative or the positive film, and not infrequently under-exposure is in evidence as well. There is no reason why motion picture work should not be treated in a high key when the aim is pictorial, although it seems to be the case that a film handled in a low key is not apt to be so effective as is the case with a print. Should the negative film be incorrectly exposed or developed, it will be found advisable to correct these errors at the time of printing rather than to attempt either intensification or reduction.

Development may, of course, be either by inspection or by time, but whichever method is used the developing frame should be turned end for end several times in the tank in order to prevent uneven development. When development is complete the film is fixed for the proper length of time in the fixing tank and is then transferred to the washing tank. The remarks as to fixing and washing, especially with regard to having the inflow of water at the top of the washing tank and the outflow at the bottom, apply to motion picture films as well as to ordinary photographic work.

Drying.—After the film is washed it may be wound off the developing frame to the drying drum, which latter should be supported on trunnions or an axle, and is then set aside in a dry room free from dust. It is not advised to dry the film in the dark room, both because the atmosphere in the latter is likely to be damp and because there are apt to be particles of chemical dust floating in the air, it being even more important to keep the film free from dust and spots than is the case with ordinary photography, since pin-holes are difficult to spot on a motion picture film, and if not spotted show very conspicuously on the screen.

Printing.—Printing is done on a strip of film similar to that used for the negative except that the emulsion is much slower. There are many forms of printers on the market, some manufacturers arranging their cameras so that by the use of an additional bracket the camera itself may be used for printing. The main points in printing are to keep the positive and negative films in contact, to draw them at a uniform rate of speed past a constant illumination, and to adjust this rate of speed so that the positive film receives the proper exposure. Until considerable experience has been gained it will be well to print a few test slips of a foot or so of film, developing and fixing these in order to determine whether or not the exposure has been correct. Some printers have simply a sprocket wheel the teeth of which engage the perforations in both films, thus drawing the films through the gate in front of the light with a uniform motion; whereas others are fitted with a claw and cam which draws the films through in a series of jerks, as is done in making the original nega-

tive. There seems to be no choice between these different types so far as results are concerned, the only difference being in the worker's personal preference. The subsequent operations on the positive film are identical with those on the negative film.

TONING THE POSITIVE.—For special effects, such as sunlight, moonlight, firelight, etc., it will often be found desirable to stain or tone the positive film, and many formulæ for this work can be found in the photographic annuals, the formulæ given for use with bromide papers being applicable to motion picture film as well.

GENERAL REMARKS.—Many curious phenomena are observable in motion picture work. For example, a wheel may sometimes appear to be revolving backward instead of forward, the cause of this being that successive phases of the motion are photographed slightly before a given spoke has reached the position occupied by its predecessor when photographing the first phase. Thus if we consider a wheel having, say, but four spokes and if the first phase is photographed, the second phase being photographed at such an interval thereafter that the wheel has moved through an angle of 90°, and so on, it will be apparent that the wheel will seem to be standing still. Similarly, if the different phases are photographed at such an interval that the wheel rotates through, say, 85°, it will of course appear to be revolving backward, and for it to show its true motion it is necessary that it revolve through slightly more than 90° during the interval between the photographing of successive phases.

In many cases the motion of the subject is such that a standard speed of sixteen pictures per second is in-

sufficient to secure a smooth and easy motion in the result, this being due to the circumstance that a considerable portion of each phase takes place during the time that the shutter is closed. Thus, a man walking at the rate of four miles an hour, which is an average gait, will appear to move in a jerky fashion like an automaton. In such cases the taking speed should be more rapid, and this may be secured by turning the crank of the camera faster. It has also been found that the result is much better in general if the taking speed is made from twenty to twenty-four pictures per second instead of sixteen, and it is not improbable that in the near future some such speed will be adopted for general use, though it would involve from 25 per cent. to 50 per cent. increase in the cost of the film used, and would mean changing the gearing on cameras to be used at the higher rate of speed.

Any amateur with patience can produce many interesting films by photographing slow motions at wide intervals; thus the growth of a plant may be photographed from the time that it first appears above the ground until the completion of the expanding of the bloom. To do this it is necessary to illuminate the subject by artificial light, since the picture must be taken at regular intervals throughout the twenty-four hours of the day, and a special spindle must be fitted which permits of making one exposure to each turn of the crank. The plant is photographed at intervals of from several minutes to several hours, depending on the rate of growth, and when this series of exposures is printed and projected upon the screen the projection may occupy one or two minutes, the entire development of

the plant being seen in that time. For this type of work much depends on the determination of the correct interval for photographing successive phases of the motion, since if this is not determined carefully the result will seem jerky and disjointed. It is also possible to photograph extremely rapid motions, such as the flight of a bullet, and to slow down the motion in projecting, thus causing the rapidly moving object to complete its travel in perhaps one or two minutes on the screen, whereas actually the motion across the space in front of the camera may have occupied not more than one three-hundredth or one four-hundredth of a second. This type of work, however, demands apparatus which is beyond the reach of the average amateur.

There seems to be no reason why motion picture work should not be fully as meritorious from an artistic standpoint as the ordinary still photography, although it must be admitted that up to the present time this ideal has not been realized, most producers being intent on securing films which will be sufficiently sensational in character to attract large crowds and be financially profitable. Unquestionably they have been tremendously successful in this respect, as is evidenced by the great sums which are spent on the production of photoplay films, such expenditure being without justification unless anticipated and actual receipts were correspondingly large. Still, it is more than probable that at some future date there will arise a producer who will subordinate the sensational to the meritorious, and the reward of such an individual will be large. At least one man is now working along these lines and has produced some wonderfully fine films.

GENERAL REMARKS

Many persons feel that the photoplay is destined to supplant the legitimate drama, but the writer does not believe that this can ever take place, since the motion picture film appeals to the eye alone and is therefore limited to a comparatively low grade of intellectual appeal and to a crude emotional stimulus. The drama, on the other hand, appeals to both the eye and the ear, and since it places actual individuals before the spectator an appeal not only through muscular and facial expression but through the ear as well is made, the spoken word being a far more potent factor in stimulating an emotional response than is the case with the eye. Should the reader be inclined to doubt this, let him try to imagine any photoplay which would be capable of arousing the feelings stimulated by the quarrel between Brutus and Cassius in Julius Caesar, or by the Council of Infernal Peers in Paradise Lost, and it will be seen that the photoplay is totally incapable of rising to the emotional heights possible to the spoken word.

CHAPTER XXI

CONCLUSION

The effort has been made, so far as is possible in a book the size of the present one, to give a discussion of the general principles of the various methods which will be found most useful to the person who wishes to express artistic impulses by means of the camera, but it has not been possible to give a complete discussion of all the photographic methods which will be of value to such a worker, since to do so would require several volumes the size of this one, and, as was stated in the foreword, no reference has been made to the many technical methods employed in commercial work. It must not, however, be supposed that the photographer can become a pictorialist of the first rank merely through familiarity with technical methods. The aim of the artist must always be to arouse in those looking at his work some emotional mood or sentiment, and to accomplish this other qualities are required beside perfect technique. The finished picture may be likened to the human being, who requires for perfect balance the three qualities of body, mind and spirit, being incomplete unless all three of these characteristics exist in due and suitable proportions. In pictorial art technique, which is purely objective, may be likened to the body; composition of line and value, being more subjective, may fitly be compared to the mind; and the spirit of the human being finds its counterpart in the

expressive impulse underlying the choice of subject and the manner of its treatment. Many workers of the present day, both painters and photographers, are content to produce a pleasing arrangement and perfect technique, feeling that a well-expressed esthetic design is all that is necessary for the production of a finished work of art. Referring to our analogy, however, it will be seen that such a picture may fitly be compared to the hedonist, who, however perfect physically and intellectually, can never leave a lasting impression on his time for lack of a high spiritual motive, and pictures of this nature can have only an ephemeral value, however pleasing they may be esthetically.

The study of composition is beyond the scope of the present book, but many works on the subject exist and there is every facility offered to the student for acquiring skill in this necessary element of art. It may be said that in general more can be learned from a careful study of black-and-white reproductions from the works of great artists than from the study of any book, since the principles of composition are merely verbal enunciations of certain arrangements which past experience has found pleasing, and a sense of composition must be so thoroughly ingrained in the worker that its expression will result without conscious effort.

The third quality, that of spirit, cannot be taught, but must result from an inherent desire to do work of an ennobling character. Even this quality, however, may be developed or may be suppressed, and the development or suppression of a lofty desire is to a great extent dependent on surrounding circumstances. It

is well known that a high order of mediocrity, in many cases but slightly separated from actual genius, may result from careful and persistent study and effort, but it is not so well known that true genius may be suppressed. There is in the minds of many persons a belief that genius will always show itself, but this is far from being the case, since great genius may be prevented from finding expression through the necessity of producing a relatively low order of work to supply a commercial demand and may also in many instances be vitiated by unfavorable personal surroundings; but it must not be supposed from this that the writer has any sympathy whatever with the so-called artistic temperament, which he believes to be merely an excuse for the artist to employ mannerisms or self-indulgences which would not be tolerated in the average individual. It will in general be found that artists of the first rank do not possess the "artistic temperament," but in the affairs of daily life conduct themselves quite as well as those individuals whose work is not of an artistic nature. On the other hand, suitable encouragement favors the development of genius, and where any spark of this exists it may be fostered by proper educational means. Unfortunately, the standard education of this country at the present time is designed to reduce all individuals to a common level, and it is to be hoped that the next few years will see a decided improvement in this respect, signs of such a change not being wanting at present.

The highest development of genius in any branch of human activity can result only from the combination of a peculiar mentality with long and arduous

study and effort, but it is by no means impossible for workers who lack the inherent gift of genius to produce artistic results of a pleasing nature and of a very high level, works which will be helpful to many persons to whom the highest productions would be of no value whatever. A certain degree of development is necessary to permit one to appreciate and benefit by any given work, and consequently the finest works of art can appeal only to those who are prepared to understand them, this class of course increasing as the development of the race progresses. Therefore no worker who finds himself lacking in great genius should despair of serving his fellow men, since he will always find an audience and this audience will always be helped spiritually if the artist's original purpose was a noble one. Everyone who feels any artistic impulse whatever should follow the direction in which it leads and may be sure that if he does so he is aiding the progress of the race.

Many workers are so limited by commercial conditions that they can give but a small portion of their time to the study and practice of art, and these are advised to adopt some one method of work and to adhere to it throughout, since a perfect knowledge of all technical methods involves so great an amount of study as to be prohibitive to one whose time cannot be given entirely to this work. Photographers who are thus restricted are advised to employ a double-coated orthochromatic or a backed panchromatic plate and to familiarize themselves with the use of platinum and gum-platinum or of oil for printing, since these methods are of wider application than any other and

in addition are about the easiest for the worker to learn thoroughly.

The writer hopes that this book may prove of value to students of photography, and is confident that anyone who will devote himself with enthusiasm to the use of the camera cannot fail to produce pictures which in addition to affording gratification to the worker himself will also prove pleasing in some degree to all who are interested in graphic art.

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